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MONTHLY WEATHER REVIEW

VOLUME 44, No. 6

JUNE, 1916

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JUNE, 1916.

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the Editor before the end of the next following month (e. g., February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for the illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

CLEVELAND ABBE, jr., Acting Editor.

VOL. 44, No. 6.
W. B. No. 589.

JUNE, 1916.

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INTRODUCTION.

As explained in this Introduction during 1914, the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW will be published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data" for the respective States, Territories, and colonies.

Beginning August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.—Results of observations by* Weather Bureau observers and others as reported to the Washington office. Occasional original papers by prominent students of seismological phenomena.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.— *Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1915. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year late.

In general, appropriate officials prepare the seven sections above enumerated; but all students of atmospherics are cordially invited to contribute such additional articles as seem to be of value.

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW but collected and published by States at selected section centers.

The data needed in Section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the REVIEW as a whole can only issue from the press within about eight weeks from the end of that month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are especially due to the directors and superintendents of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belén College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

CORRIGENDUM.

REVIEW for May, 1916: Page 276, column 1, lines 28 to 31, should appear as a footnote modifying equation (13).

SECTION I—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING JUNE, 1916.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Washington, D. C., July 25, 1916.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEWS for January, April, and May, 1916, 44:2, 179, 180, and 244.

The monthly means and departures from normal values given in Table 1 show that direct solar radiation intensities were below normal at Washington, above normal at Madison, and of about normal value at Santa Fe. A noon maximum intensity of 1.53 gram-calories per minute per square centimeter, measured at Santa Fe on the 21st, exceeds by 1 per cent any previous June noon measurement at that station.

At Santa Fe, on the morning of the 15th, the afternoon of the 23d and 28th, and on both morning and afternoon of the 26th and 27th, the measurements indicate steady sky conditions throughout the respective half-day periods. Extrapolated to zero atmosphere, and reduced to mean solar distance of the earth, the measurements give radiation intensities of 1.80, 1.79, 1.79, 1.76, and 1.72, on the respective dates. Applying the Smithsonian "Abridged procedure for determining approximately the value of the solar constant," utilizing in the process the vapor pressures of Table 2, we obtain 1.90, 1.89, 1.91, 1.86, and 1.84, respectively, or values a little lower than Abbot's mean values.

Skylight polarization measurements made at Washington on 4 days give a mean of 46 per cent, with a maximum of 59 per cent on the 1st. This latter is about the mean of monthly maximum polarization measurements for June at Washington.

TABLE 1.—*Solar radiation intensities during June, 1916.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
June 1	1.38	1.27								
2	1.22	1.13	0.84							
6		0.93								
12		0.98	0.83	0.71						
13		0.94	0.80	0.67	0.58					
17	1.26									
19			0.95	0.86						
22		1.13	1.07	0.94	0.80	0.71	0.65			
24			0.77							
28			0.66		0.54	0.48				
Monthly means	1.29	1.06	0.85	0.80	0.64	(0.60)	(0.65)			
Departure from 8-year normal	±0.00	−0.06	−0.08	−0.07	−0.19	−0.19	−0.12			

TABLE 1.—*Solar radiation intensities during June, 1916*—Continued.

Madison, Wis.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.	Gr.-cal.
June 3	1.40	1.32	1.23	1.12						
15	1.33	1.22	1.08	0.94						
17			1.15	1.06						
19	1.34		1.12	1.02						
21		1.29	1.16	1.09						
24	1.40	1.31	1.20	1.15		0.99	0.95			
25			1.23	1.10						
27	1.42	1.32	1.23	1.16	1.10	1.04				
Monthly means	1.38	1.29	1.18	1.08	(1.10)	(1.02)	(0.95)			
Departure from 6-year normal	+0.09	+0.09	+0.07	+0.03						
P. M.										
June 19		1.22								
Monthly means		(1.22)								
Departure from 6-year normal		+0.09								

Lincoln, Nebr.

A. M.										
June 3		1.38	1.30	1.22						
4	1.35	1.24	1.14	1.05	0.97	0.89				
7		1.39	1.30	1.21	1.13	1.05				
8		1.41	1.30	1.16	1.10	1.00	0.90			
9	1.44	1.35	1.27	1.20	1.09	1.02	0.87			
12			0.89							
14	1.31		1.07	0.99	0.92	0.83	0.69			
16		1.32	1.22	1.12	1.03	0.94	0.88			
17	1.27					0.88	0.79			
23	1.47	1.36								
24	1.36	1.32	1.20		1.02	0.91	0.83			
26	1.37									
29	1.27						0.73			
30	1.38	1.33	1.23	1.14	1.07	1.00	0.91			
Means	1.36	1.34	1.19	1.14	1.04	0.95	0.82			
P. M.										
June 3						0.86	0.74			
9		1.31	1.16	1.11	1.04	0.99	0.93			
16			1.14	1.05	0.97	0.91	0.85			
23		1.37	1.23	1.16	1.10	1.04	0.83			
24		1.17	1.11	0.99	0.89	0.83	0.69			
26			1.15	1.04	0.97	0.90	0.82			
28		1.18	1.08	0.96	0.88	0.80	0.73			
29		1.18	1.09	0.98	0.86	0.80	0.76			
Means		1.24	1.14	1.04	0.96	0.89	0.79			

Santa Fe, N. Mex.

A. M.										
June 13	1.50									
15		1.29	1.17	1.05	0.96					
16	1.41	1.18	1.10	1.03	0.96	0.87				
17		1.30	1.20	1.11	1.00	0.95				
19	1.46	1.37	1.28	1.19		1.08	1.00			
20	1.53		1.33	1.26	1.20	1.13				
21	1.54	1.43	1.37	1.32	1.27	1.22				
22	1.53	1.44	1.30	1.26	1.23	1.19				
23	1.53	1.44	1.38	1.33	1.28	1.23				
24		1.41	1.32	1.23		1.12	1.07			
26	1.52	1.44	1.37	1.31	1.26	1.21	1.16	1.11		
27		1.34	1.24	1.15	1.07	1.09	1.03			
28	1.53	1.39	1.31	1.27	1.14	1.08				
29	1.49	1.42	1.29		1.24	1.18	1.10			
30	1.44	1.38	1.32	1.24	1.20	1.15				
Monthly means	1.50	1.37	1.28	1.21	1.15	1.12	1.07	(1.11)		
Departure from 4-year normal	±0.00	−0.01	−0.02	−0.02	±0.00					
P. M.										
June 13		1.43	1.36	1.29	1.19					
15		1.27	1.23	1.09	1.03					
16						0.89	0.84			
20		1.41	1.32	1.23						
21			1.42							
22		1.39	1.33	1.26	1.20	1.14	1.09			
23		1.43	1.34	1.26	1.14	1.10				
26		1.40	1.31	1.22	1.15	1.06	1.01			
27			1.28	1.21	1.14	1.08				
28		1.44	1.35	1.28	1.19					
29		1.36								
30		1.39	1.34	1.24	1.19	1.15	1.10			
Monthly means		1.39	1.33	1.23	1.15	1.07	1.01			

From Table 3 it is seen that at both Washington and Madison there was a deficiency of radiation for the month, amounting at Washington to 4.6 per cent of the average June total, and at Madison to 1.2 per cent. At Washington the deficiency since the first of the year is 7.1 per cent, while at Madison the departure from the normal is insignificant.

TABLE 2.—*Vapor pressure at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.			Santa Fe, N. Mex.		
Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m.	8 p.m.	Date.	8 a.m	8 p.m.
1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*	1916.	*Mm.*	*Mm.*
June 1	5.79	8.81	June 3	9.14	8.81	June 3	7.57	12.24	June 13	3.99	2.74
2	9.47	11.38	15	9.47	8.48	4	8.81	9.47	15	3.15	2.16
6	9.47	11.38	17	9.47	9.83	7	6.76	5.56	16	4.75	3.45
12	13.13	12.68	19	8.81	10 97	8	6.50	6.50	17	4.95	3.99
13	11.81	14.60	21	7.04	7.29	9	7.04	6.76	19	5.79	2.16
17	12.68	14.10	24	9.83	8.81	12	13.13	11.81	20	2.74	2.36
19	13.61	14.60	25	9.83	11.38	14	11.81	9.47	21	3.00	2.36
22	8.48	9.14	27	8.48	9.83	16	8.18	7.57	22	3.00	2.74
24	12.68	16.20				17	8.48	12.68	23	3.81	2.26
28	16.20	16.20				23	11.38	9.83	24	3.45	3.30
						24	10.59	12.24	26	3.00	2.74
						26	14.10	10.97	27	3.30	4.57
						28	14.10	18.59	28	5.79	2.62
						29	17.96	17.37	29	3.30	3.63
						30	17.37	17.37	30	5.56	3.99

TABLE 3.—*Daily totals and departures of solar and sky radiation during June, 1916.*

[Gram-calories per square centimeter of horizontal surface.]

Day of month.	Daily totals.			Departures from normal.		Excess or deficiency since first of month.	
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Washington.	Madison.
	Gr.-cal.	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*	*Gr.-cal.*
June 1	739	548	240	245	60	245	60
2	671	323	597	176	−167	421	−107
3	445	684	700	− 51	192	370	85
4	686	708	687	189	213	559	298
5	575	689	405	77	192	636	490
6	378	293	649	−121	−207	515	283
7	134	55	596	−367	−448	148	−165
8	608	198	652	106	−309	254	−474
9	319	270	753	−185	−241	69	−715
10	351	449	356	−154	− 66	− 85	−781
11	543	642	439	36	123	− 49	−658
12	638	627	570	130	104	81	−554
13	555	440	547	45	− 87	126	−641
14	547	632	707	36	101	162	−540
15	66	518	482	−447	− 16	− 285	−556
16	164	425	737	−351	−112	− 636	−668
17	640	646	653	122	107	− 514	−561
18	627	672	585	107	130	− 407	−431
19	456	765	560	− 67	221	− 474	−210
20	508	438	407	− 17	−108	− 491	−318
Decade departure						− 406	463
21	309	730	153	−219	182	− 710	−136
22	711	335	466	181	−214	− 529	−350
23	705	462	756	173	− 90	− 356	−440
24	629	750	731	96	197	− 260	−243
25	315	755	677	−219	201	− 479	− 42
26	580	429	726	46	−125	− 433	−167
27	462	731	662	− 73	176	− 506	9
28	570	689	689	35	134	− 471	143
29	580	506	685	45	− 49	− 426	94
30	283	264	704	−253	−291	− 679	−197
Decade departure						− 188	121
Excess or deficiency since first of year. gr.-cal.						−4,736	− 69
Excess or deficiency since first of year. per cent.						− 7.1	−0.1

METEOR OF JUNE 28, 1916, OVER NORTHEASTERN TEXAS.

By HOWARD H. MARTIN, Assistant Observer, Weather Bureau.

[Dated Fort Worth, Tex., July 14, 1916.]

At 9h 11m 30s p. m. 90th Meridian Time, of June 28, a magnificent meteor burst into view in the southeastern sky. Its magnitude was somewhat greater than that of any first magnitude star. Although its course was relatively short, the time occupied in covering it was

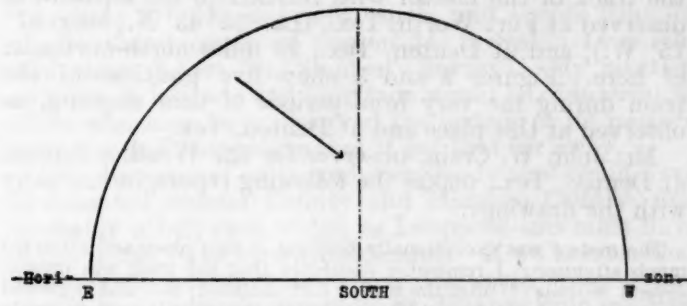

FIG. 1.—Approximate position of meteor observed at Fort Worth, Tex., June 28, 1916, 9h 11m 30s, p. m. (90th Mer. time).

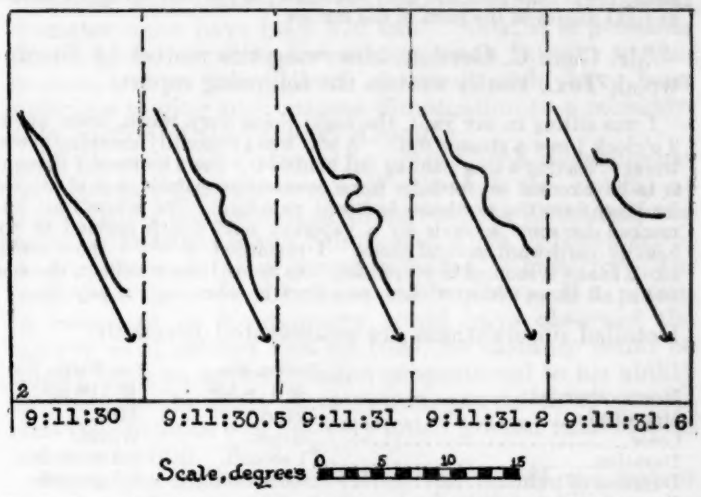

FIG. 2.—Successive relative positions of path and train of meteor at Denton, Tex., June 28, 1916, 9h 11m 30s, p. m.

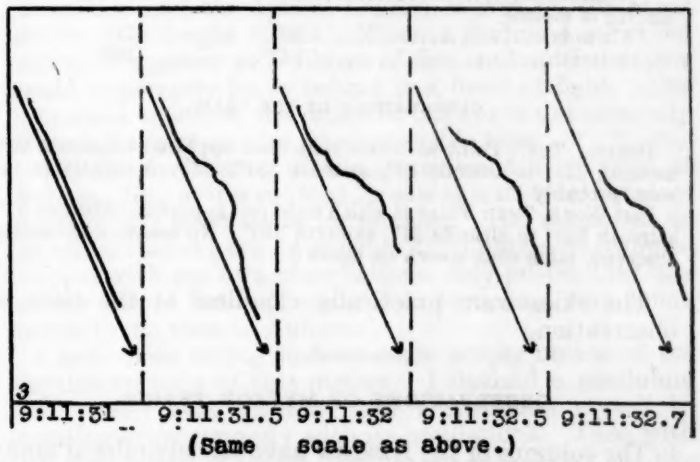

FIG. 3.—Successive relative positions of path and train of meteor at Fort Worth, Tex., June 28, 1916, 9h 11m 30s, p. m.

sufficiently great to bring about a pronounced appearance of creeping. Crudely speaking, it appeared as a gigantic serpent writhing its way across the heavens. The path was sinuous to a slight degree, and after the body of the meteor had passed, a faint smoky glowing train appeared to waver back and forth in minute oscillations, lingering for nearly two seconds after the meteor had vanished. Observations were made as accurately as possible under the circumstances and figure 1 presents the track of the meteor with relation to the horizon, as observed at Fort Worth, Tex., (Lat. 32° 43′ N.; long. 97° 15′ W.), and at Denton, Tex., 29 miles north-northeast of here. Figures 2 and 3 show five positions of the train during the very brief periods of time elapsing, as observed at this place and at Denton, Tex.

Mr. John W. Crain, observer for the Weather Bureau at Denton, Tex., makes the following report, in company with the drawings:

> The meteor was exceptionally brilliant at this place and attracted much attention. I remember distinctly that the train was present several seconds (?) after the meteor had vanished, and that it glowed like the light of a firefly. At its maximum stage of brilliance, probably two seconds after the meteor had vanished, it seemed to dart out suddenly toward the west and then withdraw only to dart out again, almost at right angles to the path of the meteor.

Mr. Clem C. Gordon, observing the meteor at Brownwood, Tex., kindly sent in the following report:

> I was sitting in my yard, the night being very warm, when about 9 o'clock I saw a strange sight. A star was apparently creeping across the sky, leaving a long flaming tail behind it. For a moment I thought it to be a rocket set forth by some overzealous patriot, but it dipped far down into the northeast before it vanished. The white trail was marked for some seconds by a vaporous mist which seemed to sag heavily earthward several times. I remarked * * * how much like a snake it seemed in its motion. As far as I can recollect, the star was at all times white, without any show of other color at any time.

Detailed observations are enumerated herewith:

	Denton, Tex.	Fort Worth, Tex.
Hours observed	9h 11m 30s.	9h 11m 30s.
Magnitude	First.	First.
Color	Green.	White.
Duration	1 second.	1.2 seconds.
Duration of train	0.6 second.	1.5 seconds.
Beginning of meteor:		
Altitude	33°	48°
Azimuth	323°.	328°.
Ending of meteor:		
Altitude	20°.	27°.
Azimuth	340°.	352°.

OBSERVATIONS OF THE TRAIN.

Denton, Tex.: Point at which train first appeared—Altitude 28°, azimuth 328° to altitude 23°, azimuth 334°. Moved slightly to the west, probably 1°.

Fort Worth, Tex.: Point at which train first appeared—Altitude 41°, azimuth 335° to altitude 34°, azimuth 340°. No east-to-west motion observed, other than shown on figure 3.

The skies were practically cloudless at the time of observation.

OBSERVATIONS OF METEOR TRAINS.

The columns of the REVIEW have already offered many instructions to those whose interests lead them to carefully observe meteors and their trains or streaks. Several observations of such trains, with remarks concerning their significance to the student of the uppermost atmospheric currents, have also been published. The recent meteor reports by Jaqua, Whitfield, and H. H. Martin show that intelligent interest in these lofty "upper air anemometers" is increasing, and as accurate observations are a sine qua non in this work the Editor here reprints some guiding remarks by C. C. Trowbridge,[1] and would again draw attention to his paper on the importance of these observations.

A. *Observations concerning the meteor nucleus.*

(1) Time of appearance of meteor nucleus and of duration of its flight.

(2) Radiant point and name of meteor (Leonid, Perseid, etc.).

(3) Color of nucleus, length of track, and length of portion of streak with respect to the entire track.

B. *Observation of the persistent train or streak.*

(4) Color of train immediately *after* disappearance of nucleus and any *change of color* of the train during the time that it is visible.

(5) Length and width of train, in degrees and minutes of arc, immediately after disappearance of nucleus, and its position in the heavens with respect to easily identified stars.

(6) Observations at short intervals of time, of the change of dimensions of the train in degrees, accompanied by a series of drawings if possible, indicating the successive changes in shape of the train. *The width of the train*, or a portion of it, *at successive intervals of time*, is of the greatest importance since it indicates the *rate of diffusion of the gaseous mass.*

(7) The displacement or drift of the train, in degrees, with corresponding time. For this purpose some *bright portion of the train* should be selected *when the train* is first seen. Also the direction of the drift *with* respect to the earth's surface, and if calculations are made of the rate in miles they should be so stated.

(8) If the intensity of the light of the train is (*a*) uniform, (*b*) brightest on the outside, (*c*) or brightest at the center; and the time of this observation after the first appearance of the meteor.

(9) Whether the train increases in brightness, this effect appears to occur not infrequently. The observer should be careful not to mistake an increase in the dimensions of the train for an increase in intensity.

(10) Spectroscopic observations, looking for the presence and position in the spectrum of one yellow line and one or two lines in the green.

(11) How long the train is visible to the naked eye, and how long visible in the telescope.

Systematic and accurate observations of persistent meteor trains will in all probability lead to results of much practical value. It is within reason to hope that light may be thrown on the following problems:

(1) The cause of the apparent self-luminosity of the meteor train.

(2) The height of the earth's atmosphere, by accurate measurement of telescopic trains.

(3) The density of the earth's atmosphere at an altitude of 50 to 65 miles, by a direct comparison with the pressure at which gas phosphorescence can occur if the meteor train is an "afterglow."

(4) The direction and velocity of currents in the atmosphere at great altitudes [unattainable by earthly means].

(5) The possible relation of atmospheric motion at high altitudes to barometric pressure, and some other facts which seem indicated by the statistical work already done, requiring further data for confirmation.

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[1] *From* the MONTHLY WEATHER REVIEW, January, 1909, 37: 13.

METEOR OF MAY 7, 1916, IN EASTERN MISSISSIPPI.

By J. H. JAQUA, Observer.

[Dated: Weather Bureau, Meridian, Miss., June 16, 1916.]

An unusually brilliant meteor moved in a southwesterly direction over western Alabama and eastern Mississippi at about 9:05 p. m. on May 7, 1916. Most witnesses who have made reports of their observations of the phenomenon agree that the meteor was first seen in a position about 45° to 60° above the horizon, and that it was visible a few seconds, probably not more than 10, disappearing in a southerly to westerly direction, below the horizon.

In color it is described as having been a brilliant yellowish white, likened in intensity by some observers to several full moons, by others comparable with a powerful automobile light or a searchlight. The illumination was sufficient to make objects visible as in bright sunlight.

Some people state that the meteor consisted of two spherical portions, which burst about the time it vanished. It is also stated by a few witnesses that sounds produced by the explosion (?) were heard. A luminous train accompanied the meteor.

Usually the details obtainable for the preparation of an article on a certain meteor must be taken from the reports of witnesses, who, as a rule, are not prepared or able to give descriptions from which accurate elevations may be deduced, but in the case of the meteor of May 7 the particularly interesting and valuable description given below has been furnished by Mr. Jesse G. Whitfield, a civil engineer of Demopolis, Ala.

METEOR OF MAY 7, 1916, AT DEMOPOLIS, ALA.[1]

By JESSE G. WHITFIELD, C. E.

[Dated: Demopolis, Ala., May 13, 1916.]

I see in the local paper [Demopolis Times] that the meteor which passed this latitude on the night of May 7 at about 9:05 p. m., Central Time[2] was also seen by residents of Mobile, Ala.

Leaving out the rising and setting of the sun, and the movement of the other heavenly bodies, to which we are now become so accustomed and at which we have ceased to wonder, I can only describe the passage of this meteor as the most magnificent of all the phenomena that I have as yet seen.

I live in the country, and on Sunday night last [May 7, 1916] was returning home from a walk to my neighbor's, when suddenly[3] the whole world seemed illuminated as if another sun had sprung into existence. I was walking toward the east, and stopped abruptly, not realizing what had happened. The body of the meteor first appeared to me in a due easterly direction, and at an elevation of 60° above the horizon (30° east of the zenith). It had an apparent diameter of perhaps one-fourth or one-third that of the moon, and in its wake was a tail of diminishing brightness some 10° in length. The meteor disappeared behind the top of a tree that stood about half a mile from me—a tree that I knew and could again identify. Without moving in my tracks, I dug a hole in the ground with my pocketknife, and next morning, with an instrument, found the bearing of the tree from the hole to be S. 20° W. Probably 10 seconds elapsed from the time of its passing my own latitude to the time of its disappearance at or near the horizon. I made the instrumental observation, hoping that some one in a widely different longitude might also note the direction of the meteor, when it appeared and when it disappeared, thus furnishing data that would enable us to approximate its distance. The meteor passed here at 5 minutes past 9 Central Time, within three minutes of the truth. My position, north latitude 32° 29′, west longitude 87° 52′, is ¼ mile north, and ⅛ mile west, of the southeast corner of section 34, township 18 north, and range 2 east (St. Stephen's survey). My position as given in latitude and longitude would be of interest to those who may have observed the meteor in its passage over the Gulf, supposing that it got that far away.

The diameter of an incandescent body that could have illuminated Sumter County and Marengo County, and probably a belt even wider, as I suppose this must have done, would have been considerable. If we assume that the meteor was 40 miles above the earth when I first saw it in an easterly direction, its distance from me must have been 46 miles, and this being true, if its apparent diameter were one-fourth that of the moon, its actual diameter must have been 570 feet. Now, it is probable that a globe of white-hot matter much inferior to this in size, and at the distance assumed, could have been sufficient to give such intense illumination to a considerable portion of the State of Alabama.

If the assumed distance be correct, the meteor must have passed directly overhead (through the zenith) at a point some 6 miles east of Uniontown, or about halfway between Demopolis and Selma, and when in that part of its trajectory, to an observer in Selma, it must have appeared in the west 60° above the horizon. If a person in Selma or in Montgomery could have observed the meteor as it crossed this latitude, its distance could be known with an approximation proportional to his ability to estimate its angle of elevation, provided, of course, that the distance was not very much greater than that of my assumption. * * *

While the matter constituting the tail of the meteor may have been visible before it lost its brilliancy by cooling, it was probably not possible to distinguish between this and the optical illusion caused by the rapid motion of a bright object. When a firebrand is waved rapidly it appears as a ribbon of fire, and so the meteor would apparently leave behind it a band of light. The impression made on the retina of the eye is not instantly effaced, but remains for an appreciable time. * * *

Mr. B. A. Wooten, of the department of physics at *Auburn, Ala.*, writes me that he saw this meteor, but does not give any estimate of its position. His statement to the effect that it gave no sensible illumination at Auburn, coupled with my own observations, only proves that the meteor passed between me and Auburn, and very much nearer to me than to Auburn.

I have been trying to form some proper notion of the angular velocity of this meteor. I devised a pendulum that would beat seconds, and accustomed myself to counting synchronously with its oscillations. Then with two straight laths nailed together, so as to open out like a V, I made three trials with results of 16°, 18½°, and 21½°, respectively, the mean of these trials being 18.8°. The mean of another series of trials was 20°. Of course, these were the crudest sort of observations. All I could do was to sight along the laths and open them out to the angle that it seemed must have been described by the meteor in an estimated one second. But if we assume

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[1] Extracts from the Demopolis (Ala.) Times of May 18, 1916, supplemented by private advices from the author.

[2] Mr. Whitfield also calls this "clock time of the 90th Meridian."

[3] This statement might be modified somewhat, for the light from the meteor did not flash up to its full brightness instantaneously as if a great electric light had been turned on, but gradually increased through perhaps two seconds, and this gradually increasing illumination caused me to stop walking and to look at the heavens. . . . I would say that the illumination was at its height a little after the meteor passed my latitude.—*J. G. W., letter of July 7, 1916.*

that the meteor was 46 miles away when first seen, and when moving in a path almost perpendicular to the line of sight, the tangent of 19° on a radius of 46 being about 16, we must conclude that the velocity of the meteor when first seen was about 16 miles per second.

The meteor passed from my latitude to the horizon in an estimated 10 seconds. *It surely passed Mobile long before it reached my horizon.* Mobile, from my point of observations, bears S. 5° 03′ W., distant 127 miles. From the point 6 miles east of Uniontown, Ala., Mobile bears S. 16° 42′ W., distant 129 miles (this is taking no account of the spherical form of the earth), and in its passage from this last point to the latitude of Mobile, with the assumed velocity, the meteor would have consumed only about 8 seconds. An object only 2 miles above Mobile would have been in my horizon.

After the disappearance of the meteor my first thought was to get a lamp and note the time. I had thought of listening for a sound, but at the moment it did not occur to me that I would have to wait probably from three to five minutes for the sound to get to me; so I heard none.

When the direction of the disappearance was taken the variation of vernier of the instrument was set for 4° 30′ E. That is to say, my assumed meridian ran N. 4° 30′ W. of the magnetic.

Note of July 7, 1916.—Shortly after the appearance of this meteor I was in *Faunsdale, Ala.*, a place 16 miles east of my point of observation, and from what I could learn it does not seem that the apparent position of the meteor as seen from that place, was different from that of my observation. I did not have the opportunity, however, of consulting one gentleman who is said to have had a good view of it while sitting on his front porch. His front porch faces due east.

WORK OF THE AMERICAN METEOR SOCIETY IN 1914 AND 1915.[1]

By CHARLES P. OLIVIER.

[Dated: Leander McCormick Observatory, University of Virginia.]

The year 1915 saw a very great increase in the interest in the study of meteors, which was evidenced by the large number of observations made by members of the American Meteor Society. This gratifying increase became largely possible on account of a grant to Dr. S. A. Mitchell, of the Leander McCormick Observatory, from the J. Lawrence Smith fund of the National Academy of Sciences. This appropriation, which was made in April, 1915, permitted the work of the Meteor Society to obtain wider publicity by the publication and distribution of bulletins, maps, and blanks to prospective members.

As a consequence it is believed that the largest amount of systematic work ever done in one year in America was sent in; the results of these observations have been prepared for publication and are now awaiting printing. Briefly, this publication will contain the results from 540 observations made by 4 persons in 1914 and from 5,003 observations made by 36 persons in 1915. While most of these 36 persons are amateurs, 5 have had astronomical training, one is a colonel in the United States Army, one is an observer of meteors in the United States Weather Bureau of wide experience, three are students in astronomy at the University of Virginia, and several others are trained in various scientific lines which would make their work the more valuable. The observers were stationed in 17 States, two Provinces of Canada, and one in the Argentine Republic. It might be added that the Meteor Society has members in several foreign countries and several dozen more in America from whom no reports have yet been received, while a week rarely passes without a new person applying for membership.

From the 5,543 observations of meteors mentioned we have been able to deduce 139 radiants of sufficient accuracy to calculate parabolic orbits for the meteor streams they represent. These orbits are contained in full in one of the tables. Following this is a table containing 81 less certain, but probably existant radiants, for which as yet no orbits are calculated. Other tables contain analyzed data of the distribution of meteors as to magnitudes and average durations of their times of visibility. There is also a table containing a few real heights, which were obtained in August, 1915, between Richmond, Va., University of Virginia, and Washington, D. C. This latter work we hope to repeat on a larger scale and under better conditions during the summer of 1916. The text of the publication contains details as to the organization, plans, and methods of reduction of the work. It further contains full explanations as to the derivation and use of the figures found in the tables. Actual directions to the members were omitted, since these had been printed at great length both in "Popular Astronomy" and also in Bulletins 2–5 of the Meteor Society, which were distributed to all members and applicants.

The present publication and the two similar ones previously prepared by me will bring up the number of results to 440 parabolic orbits of meteor streams, based on about 14,000 meteors. The peculiar value of this contribution lies in the fact that a fairly uniform plan has been followed by all the observers, and that the results were computed and deduced by one person using the methods and care with which other astronomical work is handled in all regular observatories.

It may be of interest to mention the various methods used to reach amateurs who might care to join in the work. At the very organization of this society, the cooperation of the members of the Meteor Section of the Society for Practical Astronomy was secured by the appointment of the writer as director of the latter. Then, last spring a number of articles were published by Dr. S. A. Mitchell and myself calling attention to the desirability of cooperation on the part of all amateurs. These articles appeared in the "Scientific American," "Journal of the Royal Astronomical Society of Canada," and "Popular Astronomy;" by reprinting them in part or in whole, the press of the country assisted in bringing our work to the notice of amateur observers and, as a result, wide publicity was secured. Not less than 200 people have written letters on the subject to date, over half desiring to join in making observations. It goes without saying that many have never been heard from again, but so many have worked with real enthusiasm and success, that it would seem that the future of meteoric astronomy is brighter at the present time than ever before, so far as America is concerned. This is peculiarly fortunate at such an epoch when similar societies in Europe must be greatly reduced in membership and activity.

Having secured the approbation and support of the National Academy of Sciences for the coming year, through a further grant from the J. Lawrence Smith fund, it is hoped that the results for 1916 will surpass those for the previous year, and indeed a good start has been made in that direction. We still need and desire the help of other persons interested in such work and a cordial invitation is again extended to them.

[1] *Reprinted from* Proc. Natl. Acad. Sci., Washington, July, 1916, 2: 372-4.

FIG. 1.—General view of flagpole with kite attached and the wind tower (anemometer tower) at Drexel, Nebr.

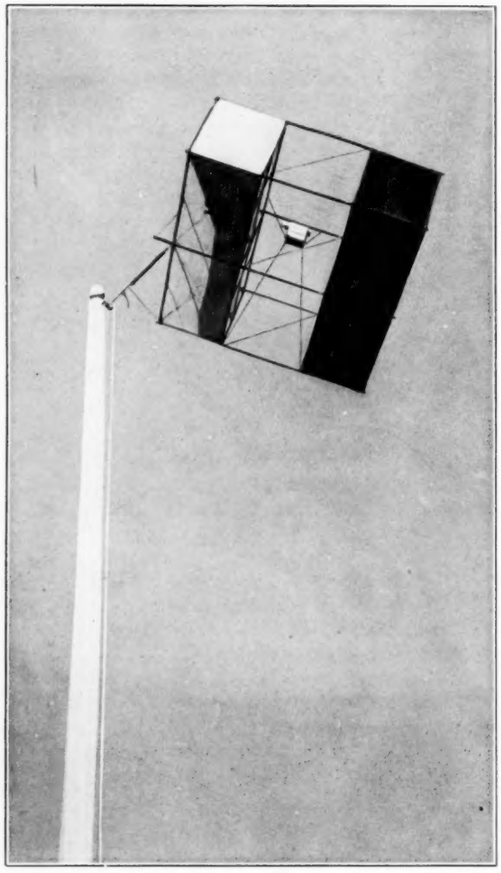

FIG. 2.—Details of attaching kite carrying the meteorograph to the flagpole during an anemometer test at Drexel, Nebr.

CANADIAN AEROLOGICAL RESEARCH.

[*Reprinted from* Nature, London, June 29, 1916, 97: 370.]

The Meteorological Service of Canada has published an interesting account of its upper-air investigation. Part I, which is now published, deals with the records of registering balloons; the work has been done and the report prepared by Mr. Patterson, under the direction of Sir Frederick Stupart, the director. Ninety-four balloons were sent up and 53 recovered, a fair proportion, perhaps, considering the nature of the country. The instruments and methods are practically the same as in England, but the balloons have all been started at 8 p. m. local time, so as to avoid solar radiation. The mean annual temperature at each height up to 11 kilometers is very similar to that in England, the temperature fall per kilometer is almost identical, but the actual temperature is a degree or two higher. In view of the lower latitude this is not surprising; but in Canada the fall of temperature continues to a greater height than in Europe, the mean value of H_c being given as 11.7 kilometers, as against about 10.7 kilometers for Europe, and in consequence the temperature of the stratosphere is from 6 to 7 degrees (C.) colder. Except in the case of the surface pressure, the variations of all the elements are larger in Canada; the amplitude of the seasonal variation of H_c is about 2 and the standard deviation is 1.96. The correlation between H_c and the pressure at 9 kilometers (P_9) is very high, but the correlation between the surface pressure and the other quantities is very small, perhaps on account of the small variation shown by the former. The most remarkable result given is that the temperature of the stratosphere over Canada is colder in summer than in winter. The number of observations is scarcely enough to establish this with absolute certainty, but they suffice to make it almost certain, and, after all, it is no more surprising than that the lowest temperatures of the stratosphere should have been found over the Equator. The general drift of the balloons, in Canada as in Europe, is toward the east, but there are a few instances of a balloon falling westward of its starting point.

THE USE OF A FLAGPOLE IN CALIBRATING KITE ANEMOMETERS AND ALSO FOR OBSERVING AT CLOSE RANGE THE BEHAVIOR OF KITES IN THE AIR.

By B. J. SHERRY, Meteorologist in Charge.

[Dated: Drexel (via Washington, Nebr.), Nebr., June 28, 1916.]

It is the custom in calibrating kite meteorograph anemometers used by the Weather Bureau to hang the meterograph from a wind vane and compare the wind velocity as recorded by the meteorograph anemometer with that recorded by a standard Robinson anemometer. The meteorograph is hung from a wind vane in order that the ventilating tube of the meteorograph, in which the anemometer is located, will always be held in line with the direction of the wind.

When a meteorograph is in actual use it is suspended within a Hargrave-Marvin box kite, and the wind is subjected to some deflection by the planes of the kite before it reaches the meteorograph anemometer. A series of tests have been made at the Drexel aerological station of the Weather Bureau to determine, if under the same conditions, the meteorograph anemometer would record the same wind velocity suspended within the kite as when hung from a wind vane.

It was found that a kite fastened by a short line to the top of a well-exposed flagpole (see figs. 1 and 2) would fly quite steadily on most days that there was sufficient wind, and a kite fastened in this manner is held more nearly at one level than is possible if a longer line fastened to the ground is used. This arrangement also gives approximately the same conditions as a kite in the free air, so far as recording the wind velocity is concerned, and at the same time gives an opportunity to get a record of the wind velocity near the kite with a standard Robinson anemometer, placed at the same level, for comparison with the wind velocity as recorded by the meteorograph anemometer suspended within the kite.

In making these tests records were obtained on more than 50 days, but about three-fourths of them were disregarded, mostly because the wind diminished during the test. Using a Robinson anemometer as a standard and considering the mean of seven of the best tests made with the meteorograph suspended within the kite, it was found that the standard anemometer recorded 2.15 miles while the meteorograph anemometer recorded one mark;[1] considering the mean of the five best tests made with the same meteorograph hung from the wind vane, it was found that the standard anemometer recorded 2.04 miles while the meteorograph anemometer recorded one mark. By eliminating the tests during which the wind velocity fell below 16 miles an hour and considering the mean of four tests made with the meteorograph suspended within the kite it was found that the standard anemometer recorded 2.10 miles while the meteorograph anemometer recorded one mark.

The results of these tests merely indicate that, under the same wind conditions, the meteorograph anemometers will record practically the same wind velocity suspended within the box kite as they will record when hung from a wind vane. It is important, however, in making tests of this kind, that the wind vane be large enough to point true when the meteorograph is hung from it. A special wind vane was constructed for this purpose at Drexel.

In making these anemometer tests, with the meteorograph suspended within the kite, and the kite attached by means of a short line to the top of the flagpole, some useful information was obtained concerning the kites. It frequently happens that kites of the same dimensions, and that appear to be similar in every respect, will behave quite differently in the air. At Drexel, where about 40 kites are generally kept on hand, there usually have been several of these kites that would not fly satisfactorily. These defective kites would not lift the kite wire, but would usually fly sidewise, pulling down other kites attached to the same wire, and practically ruining kite flights in which they were used. Kites that had been used daily for several months, and had given excellent results, would, after being used in a high wind, sometimes become defective, and they would have to be rebuilt before they would again fly satisfactorily. Efforts had been made to locate the defects in these kites without success. It was known that with a weak stick somewhere in the framework of the kite, the strain of the wind on the sails of the kite would be sufficient to distort the kite and thus cause it to fly sidewise, but as the defect was not apparent until the kite was in the air it was difficult to locate. Any attempt to observe the kite for any length of time while it was flying near the ground usually ended with the kite diving to the ground and being smashed.

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[1] The anemometer used in the kite meteorograph consists of a windmill wheel geared to a cam. The pen makes a "mark" on the record sheet for every rotation of the cam. The spacing of these marks, when the meteorograph is exposed to a given air current, indicates the speed of the current but is peculiar to the instrument. It depends not only on the gearing but also on the angle at which the blades of the windmill are set and also on the friction of the whole mechanism. While the gearing may be duplicated, the angle of set of the blades and the friction can only be duplicated within certain limits. The friction of the parts may vary somewhat with use. Therefore, each instrument must be recalibrated occasionally.—*W. R. Blair*

By attaching one of these defective kites, with a short line, to the top of a flagpole, an observer has a good opportunity to study the kite from various angles at close range, with a good prospect of detecting the defects in the kite. By using this method at Drexel it has been possible to locate the weakness in the various defective kites, and with the aid of a piece of twine to so brace these kites that they would fly entirely satisfactorily.

SOLAR VARIABILITY.[1]

By C. G. ABBOT and others.

[Author's summary.]

We have repeated at Mount Wilson, in 1913 and 1914, with improved apparatus, the determinations of the distribution of brightness along the solar diameter described in volumes 2 and 3 of the Annals of the Astrophysical Observatory. More than 40 days' determinations were secured in 1913 and more than 80 in 1914.

[1] *Abbot, C. G., Fowle, F. E., & Aldrich, L. B.* On the distribution of radiation over the sun's disk and new evidences of the solar variability. Washington, 1916. 24 p. pl. 8°. (Smithsonian misc. coll., v. 66, no. 5. Publ. 2412.)

The results agree closely with those obtained at Washington in 1907 for all wave lengths for which a comparison is possible.

There are, however, slight but significant differences between the mean results of different years. Taking 1913 as the standard year, greater contrast of brightness between the sun's center and edge was found in 1907 and 1914 than in 1913. We incline to connect these changes with solar activity, greater contrast prevailing along with greater solar radiation at times of high solar activity.

Besides these long-period changes there appear to be small changes of contrast from day to day, correlated with the changes of the solar radiation heretofore discovered by us. For this type of changes increased contrast is associated with decreased solar radiation.

We are thus led to consider two causes of change existing in the sun. One, going with increased solar activity, we regard to be increased effective solar temperature which naturally produces increased radiation and increased contrast. The other, altering from day to day, we regard to be increased transparency of the outer solar envelopes which naturally produces increased radiation but decreased contrast.

All these changes are greater for shorter wave lengths.

SECTION II.—GENERAL METEOROLOGY.

TROPICAL RAINS—THEIR DURATION, FREQUENCY, AND INTENSITY.

By OLIVER L. FASSIG, Professor of Meteorology.

[Dated: Weather Bureau, Baltimore, Md., Jan. 3, 1916.]

The aim of the following discussion is to determine, by accurate measurements and calculations, the duration, frequency, and intensity of tropical rains and to compare the results obtained with similar measurements made in the middle latitudes.

For this purpose a representative area within each of the zones was selected in which accurate and detailed observations are available for a period sufficiently long to establish reliable normal values. The Tropics are represented by the island of Porto Rico, in the West Indies, and the Temperate Zone by the State of Maryland.

Attention is also directed to the influence of topography on the distribution and character of the rainfall in Porto Rico, and to the relation of the rainfall to the principal commercial crops, namely, sugar cane, coffee, tobacco, citrous fruits, and pineapples.

A. DURATION OF RAINS.

Tropical rains are of short duration, compared with the rains of middle latitudes, owing to the greater freedom from cyclonic storms in the Tropics. The duration of rains at San Juan is less than an hour, while at Baltimore, Md., it is about eight hours. The tropical rains are of fairly uniform duration in all months, while in the high latitudes the winter rains last decidedly longer than those of the summer months. At Baltimore rains of the colder half year continue about 10 hours and those of the warmer months less than 4. The explanation of this difference in duration is found in the greater frequency of the cyclonic storms of the winter season. The rains of the Tropics closely resemble the summer rains of the middle latitudes during a spell of unsettled weather. (Table 1 and fig. 1.)

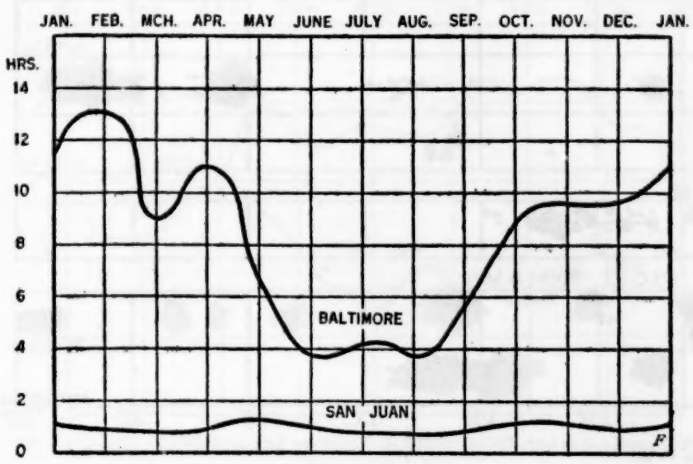


FIG. 1.—Average duration of rains (hours and minutes) at Baltimore, Md., and San Juan, P. R.

TABLE 1.—*Duration of rainfall (in hours and minutes).*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	No. of rains.
San Juan (average 3 years)	0:59	0:40	0:50	0:54	1:12	0:52	0:54	0:52	0:57	1:05	0:54	0:43	0:53	1,538
Baltimore (average 10 years)	11:10	13:10	8:45	11:00	7:00	3:30	4:00	3:30	5:15	8:05	9:25	9:20	7:50	3,000
San Juan (dry year, 1907)	0:38	0:39	0:28	0:40	0:54	0:48	0:31	0:34	0:26	0:49	0:36	0:31	0:36	597
San Juan (wet year 1910)	0:58	0:46	1:03	1:23	1:07	0:44	0:38	1:01	1:29	0:51	1:02	1:21	1:01	460

The duration and character of rains is shown in an unusual manner by the use of what may be termed "rain autographs." These are automatic records made by the rain drops falling upon specially prepared sheets of paper covering a revolving drum, the drum being under cover, with the exception of a small aperture in the top of the cover.

The records show not only the time of beginnings and endings of the lightest rains, but their frequency and, in a rough way, their intensity. (Fig. 2A and 2B.)

Duration of excessive rains.

On comparing what are officially designated as excessive rains,[1] it is found that their duration is greater in the Tropics than in the higher latitudes. This is shown by comparing, for instance, the average duration of excessive rains at San Juan, P. R., and at Baltimore, Md. The comparison covers a period of 10 years (1894 to 1903) at Baltimore, and of 12 years (1899 to 1910) at San Juan, and includes all of the rains of the respective periods classed as excessive by the Weather Bureau. The average duration of excessive rains at San Juan is 35 minutes, and at Baltimore 20 minutes (Tables 2 and 3).

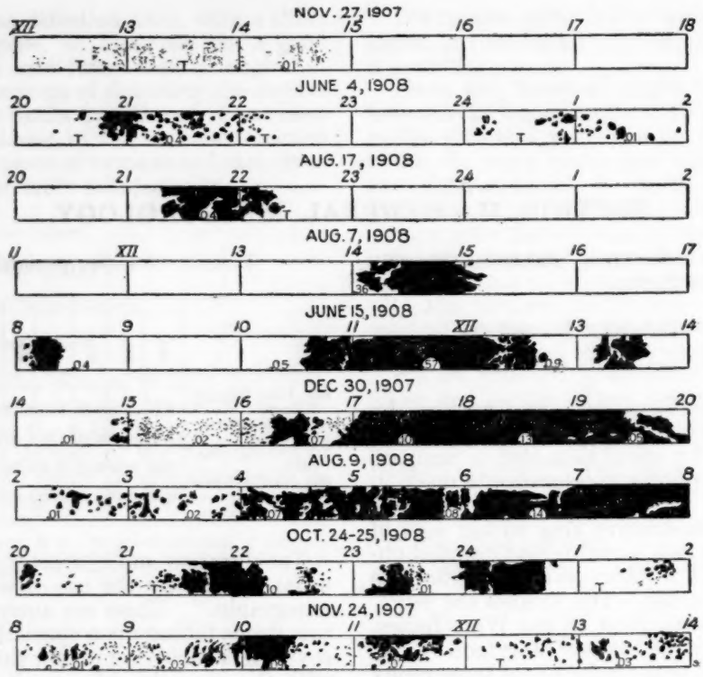
TABLE 2.—*Average duration of excessive rains (in minutes).*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Cases.
San Juan, P. R. (12 years)	39	20	37	59	43	19	28	26	35	31	34	45	35	193
Baltimore, Md. (10 years)	22	....	6	19	18	21	24	22	26	....	....	20	20	78

Limits at which precipitation may be considered excessive.

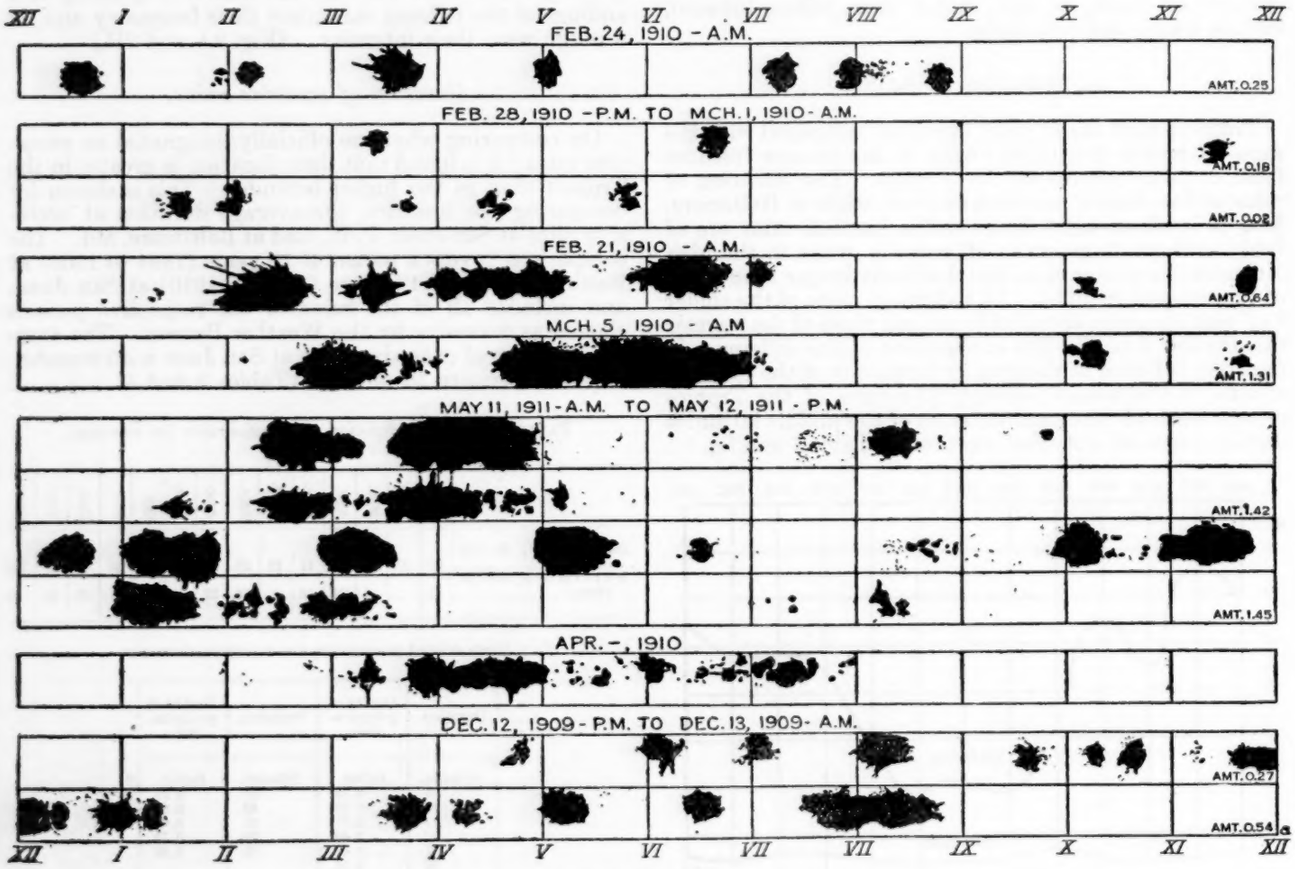
Duration.	Depths of precipitation.	Duration.	Depths of precipitation.
Minutes.	*Inches.*	*Minutes.*	*Inches.*
5	0.25	35	0.55
10	0.30	40	0.60
15	0.35	45	0.65
20	0.40	50	0.70
25	0.45	60	0.80
30	0.50		

[1] Precipitation will be considered excessive when it equals or exceeds 2.5 inches (63.5 mm.) in 24 consecutive hours, or 1 inch in 1 hour. ...



A. Baltimore, Md.

(Hourly amounts in hundredths of an inch given by small figures within the hour spaces, XII=noon.)



B. San Juan, P. R.

(Subdivisions represent hour intervals, 12-hour totals in inches at the right.)

FIG. 2.—"Rain autographs" or automatic records showing duration and intensity of rainfall at Baltimore, Md. (A), and at San Juan, P. R. (B).

TABLE 3.—*Greatest duration of excessive rains (in minutes).*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Cases.
San Juan, P. R. (12 years)	95	20	75	110	170	39	80	140	102	68	81	95	170	193
Baltimore, Md. (10 years)	22	....	6	....	37	30	80	50	45	61	....	....	80	78

B. FREQUENCY OF RAINS.

Rainfall frequency is so largely a matter of local topography that it is a difficult matter to make a comparison which will fairly represent the difference between the tropics and the middle latitudes in this respect. The average monthly and annual number of days with rain for the entire island of Porto Rico is compared with that of the entire State of Maryland. In both cases the numbers represent the average of about 40 stations for a period of 15 to 20 years.

The value of such a comparison is of course largely dependent upon the representative character of the region selected. Both regions show a fairly even distribution of rainy days through the year. The greater frequency of rains in the tropical region is to be expected, owing to a higher mean temperature and humidity (Tables 4 and 5, and fig. 3).

TABLE 4.—*Total frequency of rains.*

	Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
San Juan (10 years)	20	14	17	17	17	17	19	20	18	17	19	21	213
Porto Rico (16 years), 40 stations	14	10	12	11	14	14	15	15	16	16	15	14	166
Baltimore (44 years)	12	11	13	11	11	11	11	11	9	9	9	11	129
Maryland (20 years), 40 stations	10	8	10	9	9	10	10	10	7	7	7	8	105

TABLE 5.—*Frequency of stated amounts of rainfall.*

	0.01 to 0.10 inch.	0.11 to 0.25 inch.	0.26 to 0.50 inch.	0.51 to 1.00 inch.	Over 1 inch.	Total annual frequency.	Total number of rains.
Annual frequency:							
San Juan, P. R.	96	43	34	21	15	209	2,300
Baltimore, Md.	56	25	22	18	10	131	4,300
Percentage of frequency:	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*		
San Juan, P. R.	46	21	16	10	7	209	2,300
Baltimore, Md.	43	19	17	14	8	131	4,300

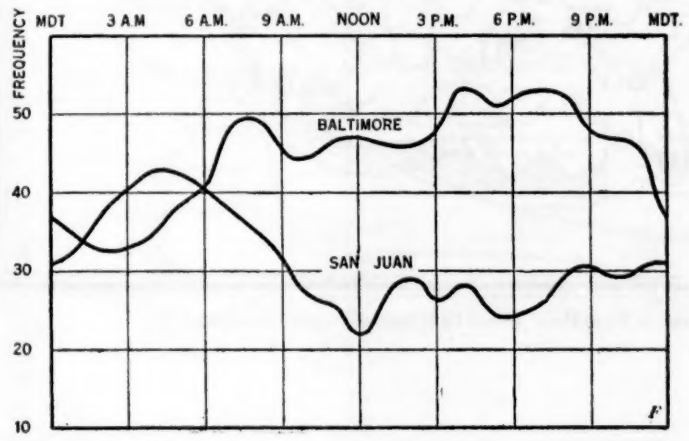


FIG. 3.—Hourly rainfall frequency per annum at Baltimore, Md., and at San Juan, P. R.

Frequency of excessive rains.

In comparing the frequency of *excessive* rains we find a much greater difference. For example, during a 12-year period (1899–1911) at San Juan there were 193 excessive rains as compared with 78 at Baltimore during a period of 10 years. Allowing for the difference of two years in the periods, the frequency at San Juan is more than double that at Baltimore.

The distribution through the year is more uniform in the Tropics than in the middle latitudes; in the latter zone the excessive rains are confined almost entirely to the summer months. The influence of the hurricane season is clearly shown in the figures for July to November in the Tropics (Table 6).

TABLE 6.—*Average frequency of excessive rains.*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
San Juan (12 years)	12	1	6	11	16	19	24	27	25	20	20	12	193
Baltimore, Md. (10 years)	1	0	1	0	13	13	18	20	8	3	....	....	78

Frequency of stated amounts of rainfall.

A matter of very great moment in agricultural pursuits, the importance of which is generally overlooked, is the frequency of stated amounts of rainfall and their distribution through the year. Frequent moderate rains are generally more favorable for plant growth than heavier rains, assuming equal total amounts for the year. There is a wide range in the frequency of rains of 0.01 to 0.10 inch in Porto Rico, a condition which is probably common to all regions with pronounced differences in topography. As the amounts grow larger the range rapidly decreases (fig. 4).

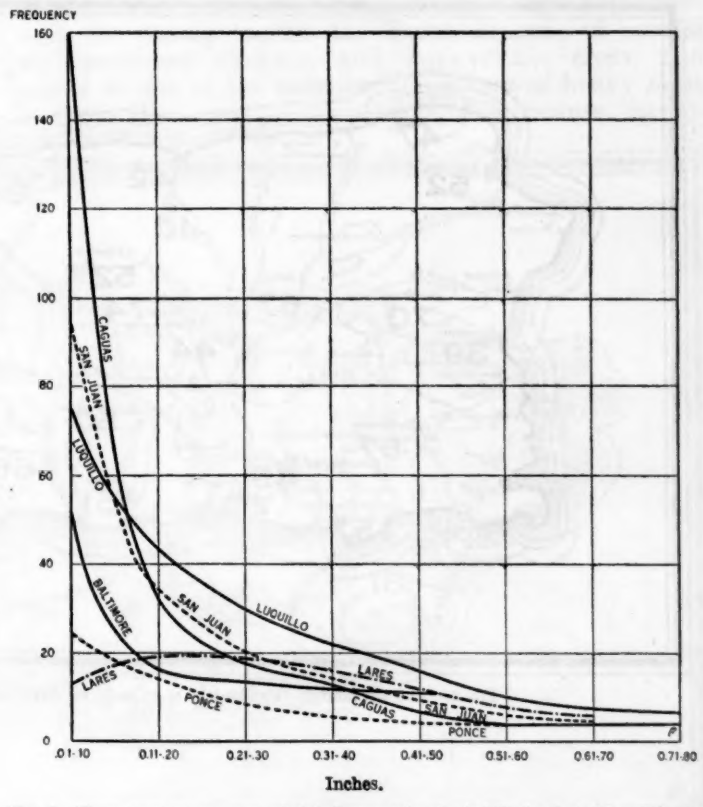


FIG. 4.—Frequency per annum of stated amounts of rainfall at selected localities in Porto Rico and at Baltimore, Md.

The best and most extensive tobacco plantations of Porto Rico are situated in the portion of the island having the greatest number of light rains, with a total annual amount close to the average for the entire island. The station at Caguas, typical of this region, shows a record of 160 days with rainfall from 0.01 to 0.10 inch, with a total annual frequency of 262 days and a total rainfall of 68 inches.

In the mountains of the western portion of the island, a region noted for the abundance and fine quality of its coffee, the rainfall is very heavy. A peculiarity of the rains of this region is that they show a maximum frequency of amounts between 0.20 and 0.30 inch, whereas the usual record shows a very decided preponderance of amounts less than 0.10 inch.

C. INTENSITY OF RAINFALL.

A comparison of excessive rates of rainfall at San Juan and at Baltimore reveals some interesting facts. The heaviest half-hour rainfall at Baltimore, during a period of 15 years, shows a greater intensity than the heaviest half-hour fall at San Juan during a similar period. However the Baltimore rainfall in question continued excessive but little more than 40 minutes, while at San Juan the rate was excessive for 1 hour and 40 minutes.

Still more surprising are the curves of figure 7, showing the average values for all excessive rains at Baltimore and at San Juan for a period of 10 years. The curves are identical for the first 15 minutes after which the San Juan curve drops below the Baltimore curve and continues well below to the end of the excessive rate of fall. Again the San Juan rains show a longer period of excessive rates, averaging 1 hour and 20 minutes for Baltimore and 2 hours for San Juan.

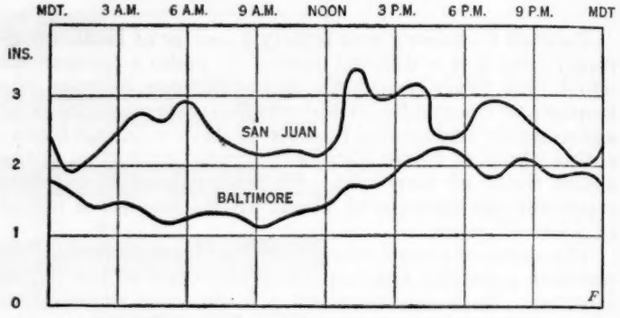


FIG. 5.—Curves of average hourly rainfall, per annum, at Baltimore, Md., and San Juan, P. R.

TABLE 7.—*Average hourly amounts of rainfall per year at San Juan, P. R., and at Baltimore, Md. (Inches.)*

	Hour ending—A. M.												P. M.											
	1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Mdt.
San Juan	0.70	0.68	0.70	0.75	0.72	0.84	0.71	0.80	0.73	0.94	1.04	1.18	1.56	1.19	1.32	1.32	1.28	1.44	1.45	1.26	0.99	0.95	0.77	0.89
Baltimore	1.87	2.17	2.33	2.72	2.56	2.93	2.51	2.32	2.13	2.18	2.20	2.10	3.44	2.96	3.01	3.15	2.39	2.47	2.93	2.85	2.59	2.41	1.98	2.36

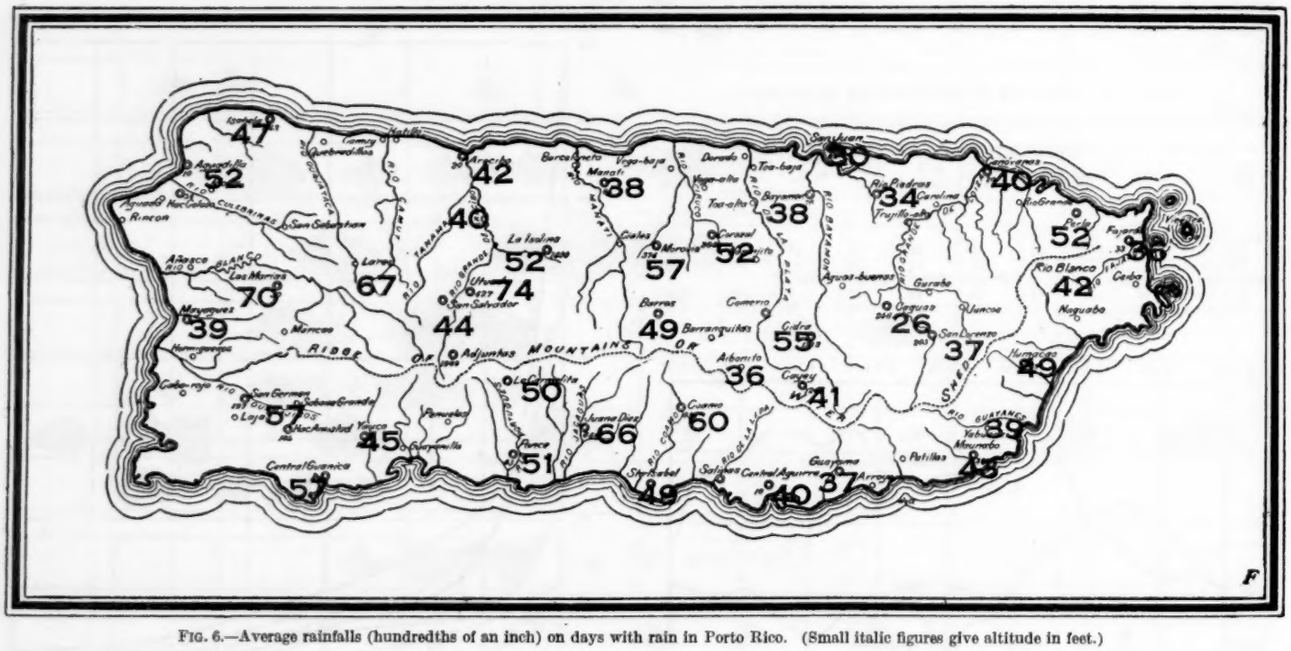


FIG. 6.—Average rainfalls (hundredths of an inch) on days with rain in Porto Rico. (Small italic figures give altitude in feet.)

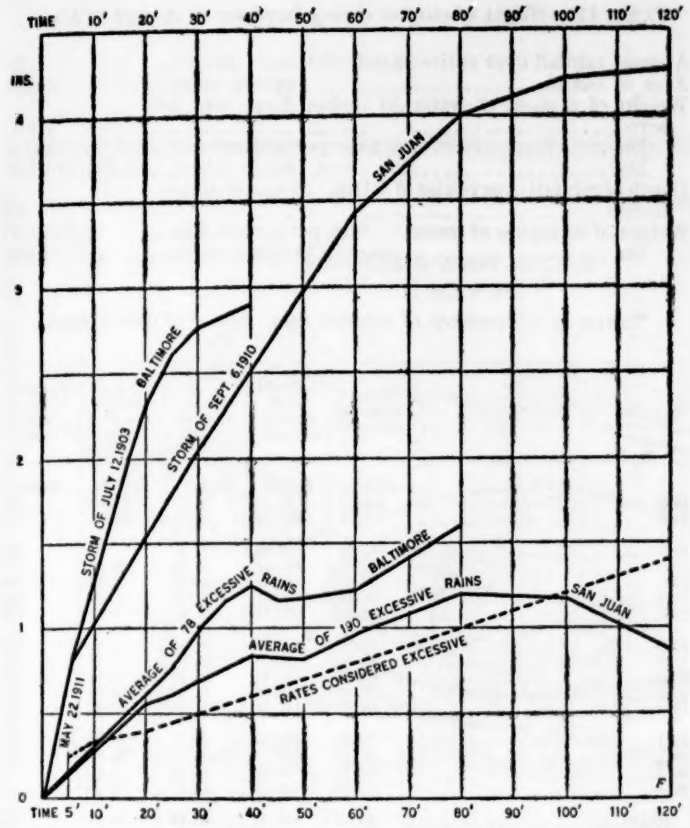


FIG. 7.—Various excessive rainfalls at Baltimore, Md., and at San Juan, P. R. Dotted line indicates rates at present called "excessive" by the U. S. Weather Bureau.

TABLE 8.—*Average rainfall on days with rain, San Juan, P. R., and Baltimore, Md. (Inches.)*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
San Juan	0.23	0.15	0.20	0.29	0.32	0.35	0.32	0.38	0.37	0.35	0.40	0.30	0.31
Baltimore	0.26	0.32	0.31	0.29	0.30	0.37	0.41	0.38	0.41	0.30	0.30	0.29	0.32

TABLE 9.—*Greatest intensity of rainfall at San Juan, P. R., and at Baltimore, Md.*

	Minutes.					
	5	10	15	30	60	120
Greatest precipitation in:	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
San Juan, P. R.	0.79	1.02	1.31	2.09	3.43	4.21
Baltimore, Md.	0.80	1.35	1.92	2.75	2.87	2.87
Rates per hour:						
San Juan	9.48	6.12	5.24	4.18	3.43	4.21
Baltimore	9.60	8.10	7.68	5.50	2.87	1.44

TABLE 10.—*Weight of rainfall.*

[A—Storm of Sept. 6, 1910, at San Juan, P. R. B—Storm of July 12, 1903, at Baltimore, Md.]

Duration.	Depth.		Tons per acre.	
	A San Juan.	B Baltimore.	A San Juan.	B Baltimore.
	Inches.	*Inches.*		
First 5 minutes	0.08	0.33	9	37
First 10 minutes	0.25	0.98	28	111
First 15 minutes	0.40	1.72	45	195
First 30 minutes	0.95	2.69	107	304
First 45 minutes	1.71	.....	194	.....
First 60 minutes	2.61	.....	295	.....
First 80 minutes	3.98	.....	450	.....

The seasonal distribution of rainfall in Porto Rico.

Accompanying charts (figs. 14 and 15) show the normal annual distribution over the island and the distribution during a dry year (1907) and during a wet year (1901). The striking features of the geographical distribution are the comparatively light rainfall on the south side and the comparatively heavy rainfall through the center of the island. This distribution is readily accounted for by the topography of the island (figs. 12 to 15).

The rainfall of November, 1901, shown in the accompanying map, represents the geographical distribution of rain during a month of frequent heavy rains associated with the passage across the North Atlantic of several well-developed cyclonic and anticyclonic areas, and points to one of the most prolific causes of heavy rains in Porto Rico, next to the passage of hurricanes (fig. 8).

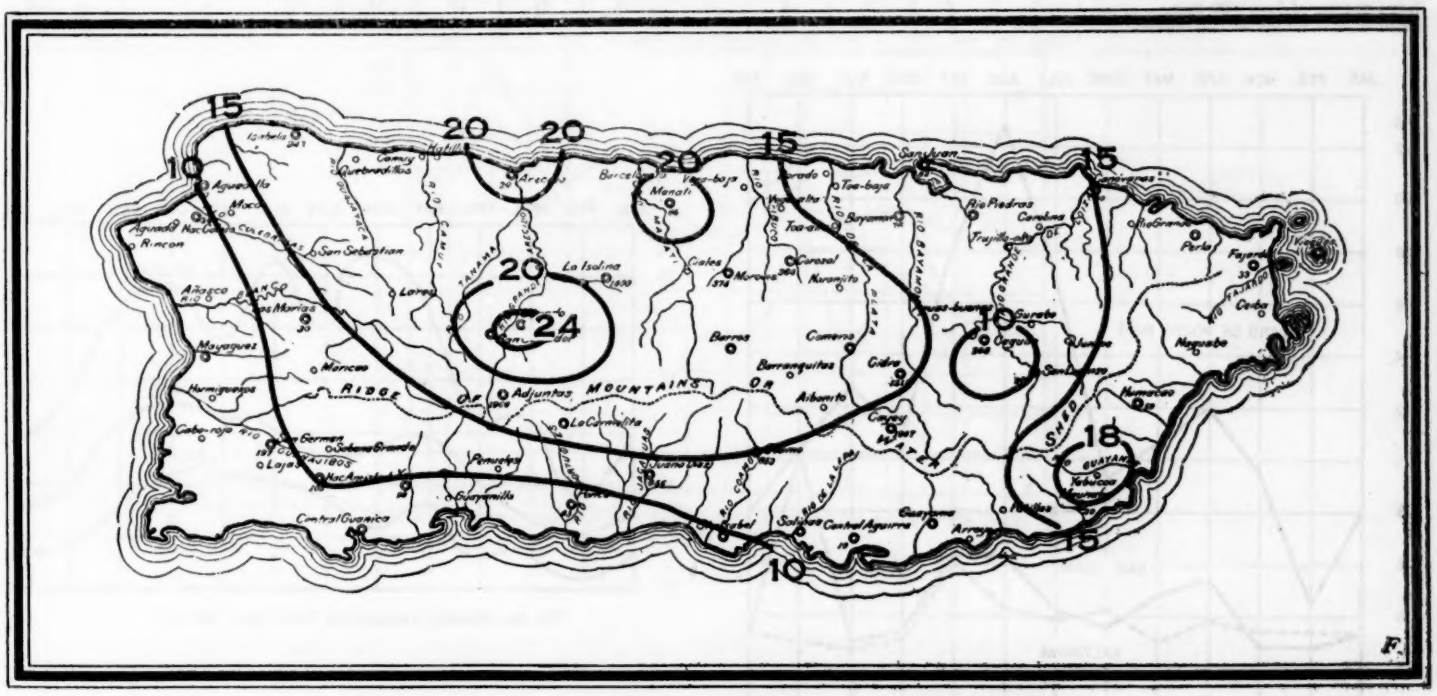


FIG. 8.—Porto Rico rainfall (inches) for November, 1909. [A wet, stormy month. A succession of pronounced HIGHS and LOWS crossed the North Atlantic, extending their influence into the Tropics.] (Small italic figures give altitudes in feet.)

Hurricanes and rainfall in Porto Rico.

The heaviest general rains of the island are associated with the passage of hurricanes in the comparatively rare instances in which the center of a tropical cyclone or a secondary development therefrom passes over or very close to the region in question. The only exceptionally severe storm of this character in recent years, one which devastated the island to an unusual extent, occurred on August 8, 1899. It is one of the historic storms of the West Indies. The center of this storm passed directly across the center of Porto Rico from east to west, and the rainfall was accurately measured by trained observers all along the path of the storm.

A cross section of the storm as it passed over San Juan was shown in a diagram [2] by means of hourly observations of all the principal weather conditions. The rainfall distribution and progressive movement of the storm across the island are shown in figure 11. The entire path of the storm, from its inception east of the Windward Islands to the Florida coast, thence northeastward along the Atlantic coast to the banks of Newfoundland was shown in the chart forming Plate XVIII of Weather Bureau Bulletin X.

The weight of water precipitated upon the island of Porto Rico in the 30 hours during which the storm prevailed has been computed. Basing the calculations an average fall of 10 inches over the entire island, the total weight of the rainfall was approximately 2,602,920,000 tons, equivalent to 723,200 tons per square mile or 1,113 tons per acre.

[2] *See* Hurricanes of the West Indies, by O. L. Fassig. Washington, 1913 (W. B. Bull. X) Plate XVI.

TABLE 11.—*Weight of rainfall during hurricane of August 8, 1899.*

Average rainfall over entire island (30 hours)..inches..	10
Area of island.....square miles..	3,600
Weight of a sheet of water 10 inches deep, tons per acre.....	1,130
Do.....tons per square mile..	723,200
Do.....tons, whole island..	2,602,920,000
Depth of rainfall over center of island (25 square miles), inches.....	23
Weight of 23 inches of water....tons per square mile..	1,663,360
Do.....tons over 25 square miles..	41,584,000

TABLE 12.—*Summary of rainfall data, Island of Porto Rico.*

Year.	Total annual rainfall.	Greatest local annual rainfall.	Least local annual rainfall.	Greatest rainfall in 24 hours.	Number of days with rain.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Days.*
1899	80.40	140.06	50.62	**23.00**	**182**
1900	77.52	151.92	39.89	12.23	172
1901	**93.82**	**168.96**	38.51	17.02	176
1902	82.65	141.17	46.08	9.06	165
1903	69.09	115.08	21.42	6.40	152
1904	75.13	131.01	36.00	6.00	159
1905	72.08	122.13	30.12	8.05	174
1906	68.39	107.03	26.86	8.48	159
1907	63.54	99.58	20.60	7.10	171
1908	66.96	107.11	29.70	5.38	172
1909	79.65	127.45	**51.02**	12.90	167
1910	66.83	107.64	23.98	18.22	161
1911	72.58	109.31	28.77	10.30	174
1912	69.25	121.73	35.83	10.72	160
1913	64.71	99.00	23.43	6.50	171
1914	67.74	138.50	18.83	10.70	161
Means	**73.15**	**129.58**	**32.60**	**10.75**	**167**

TABLE 13.—*Summary of rainfall data for entire island of Porto Rico (1899–1914).*

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
Average rainfall (inches)	3.68	2.52	3.87	4.94	7.43	6.88	6.32	7.77	8.09	8.80	7.70	5.05	73.05
Greatest monthly rainfall (inches)	7.23	4.25	8.03	7.71	13.55	16.07	12.15	15.72	11.55	14.61	13.67	9.49	93.82
Least monthly rainfall (inches)	1.57	0.47	1.57	1.22	4.11	2.85	4.39	4.98	4.99	5.27	3.87	1.67	63.54
Greatest rainfall in 24 hours (inches)	8.10	4.55	9.32	12.23	10.70	9.06	17.02	23.00	18.22	10.72	12.90	10.55	23.00
Greatest local monthly rainfall (inches)	35.64	22.64	19.45	26.21	32.89	33.30	33.58	32.22	29.24	28.41	29.52	22.62	168.96
Least local monthly rainfall (inches)	0	0	0	0	0	0	0	0.32	0.20	0.87	0.45	0	18.83
Average number of days with rain	14	10	12	11	14	14	15	15	16	16	15	14	167
Greatest number of days with rain	17	14	18	14	20	20	20	19	18	20	19	21	182
Least number of days with rain	9	3	7	6	10	9	11	13	14	13	9	8	152
Mean departure from normal rainfall	1.8	1.4	2.0	2.2	2.3	3.8	2.4	3.3	2.3	2.8	3.4	2.5	10.8

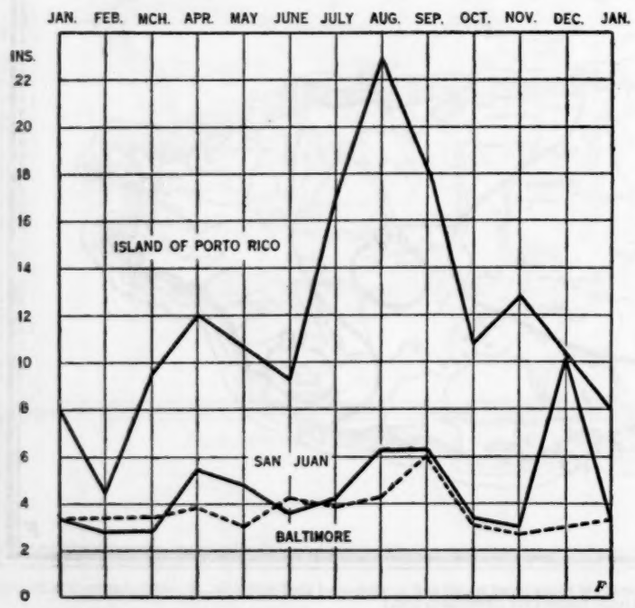


FIG. 9.—Maximum 24-hour falls for Porto Rico, San Juan, P. R., and Baltimore, Md.

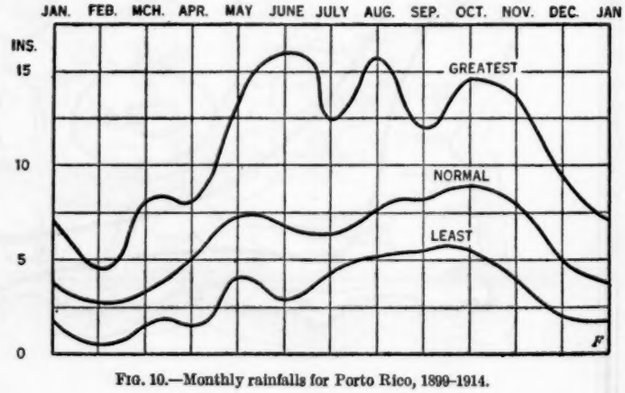


FIG. 10.—Monthly rainfalls for Porto Rico, 1899–1914.

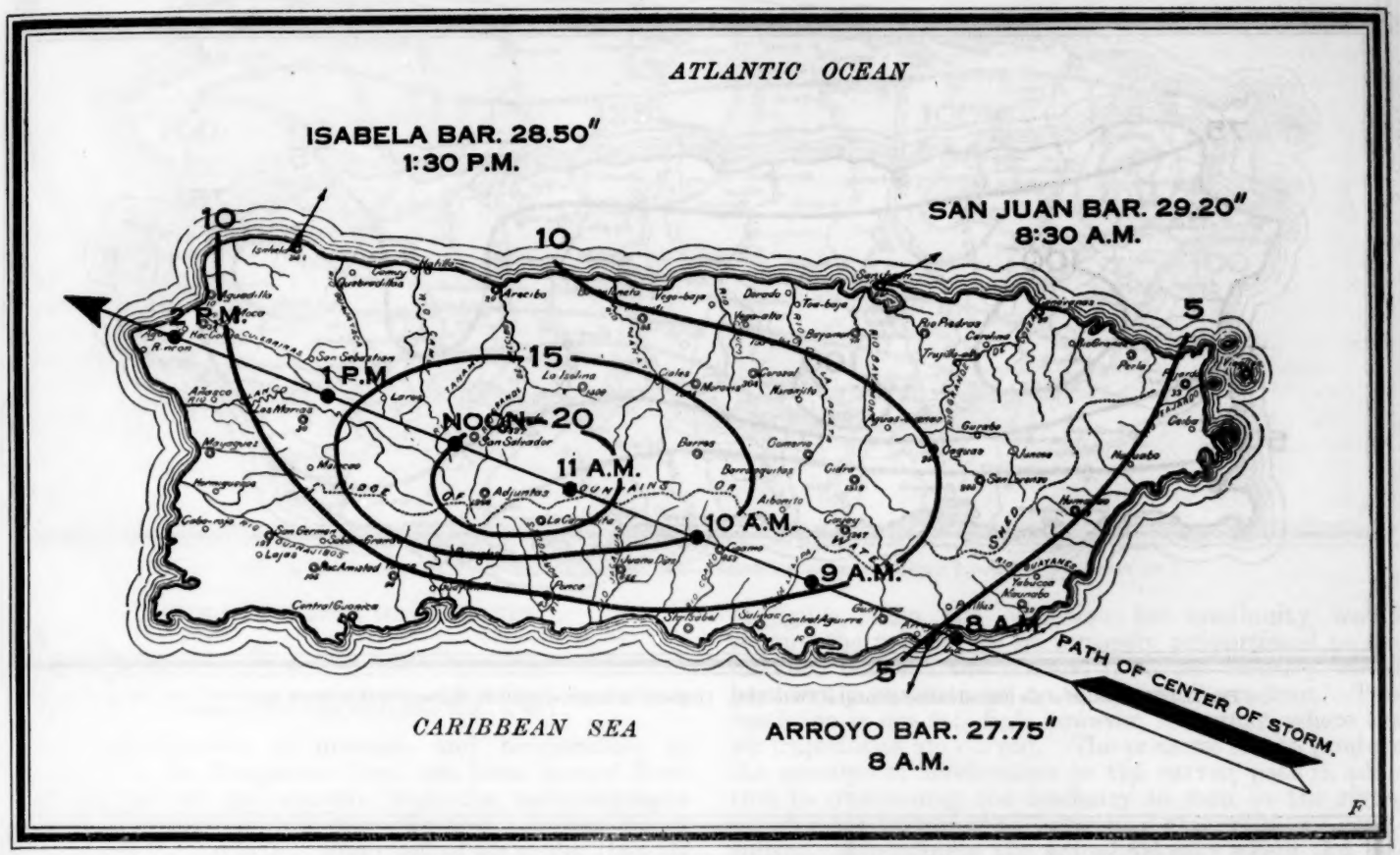


FIG. 11.—Rainfall over Porto Rico during the passage of the hurricane of Aug. 5–9, 1899. Successive positions of the center of the storm are indicated by the dots on the arrow showing its path which is about 80 miles across the island. The maximum 24-hour rainfall was 23 inches, recorded at Adjuntas.

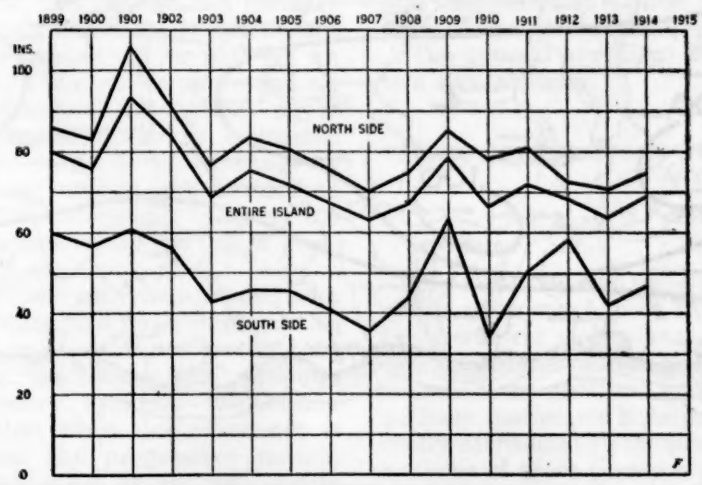


FIG. 12.—Average annual rainfalls for the two sides and the whole of the island of Porto Rico, 1899–1914.

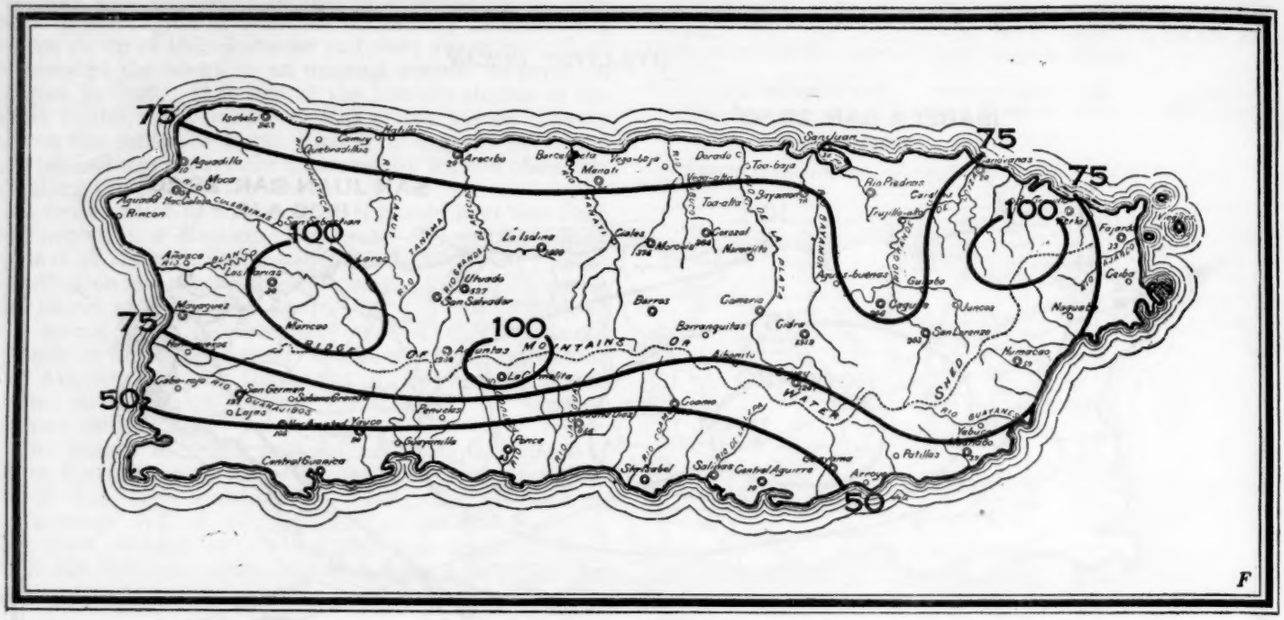


FIG. 13.—Distribution of the normal annual rainfall of Porto Rico. (Rainfall in inches; small italic figures give altitudes in feet.)

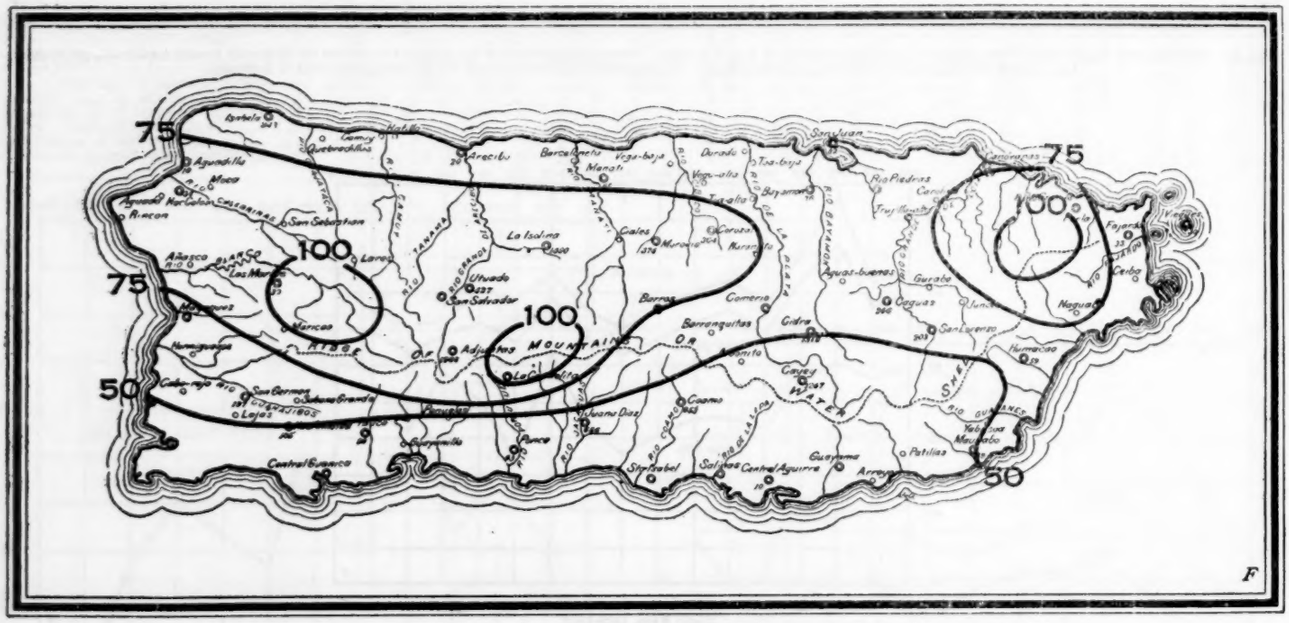


FIG. 14.—Annual rainfall of Porto Rico in a dry year, 1907. (Rainfall in inches; small italic figures give altitudes in feet.)

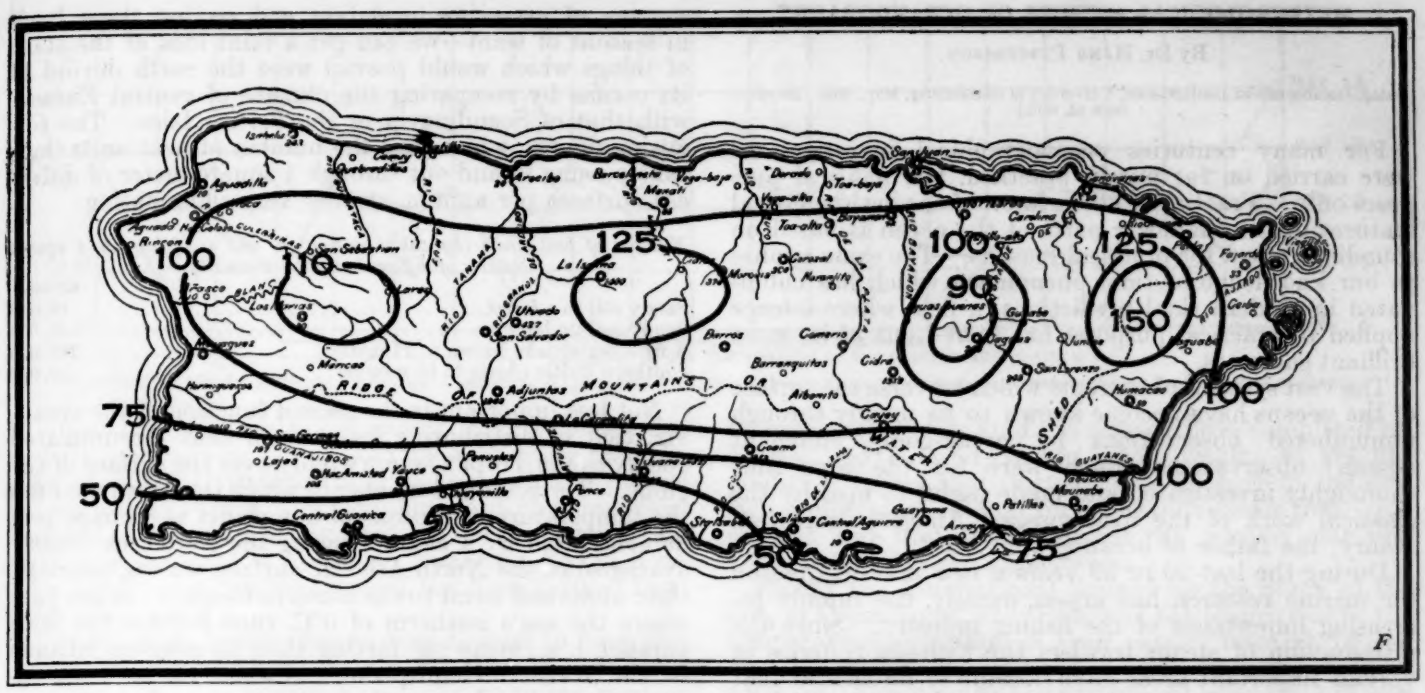


FIG. 15.—Annual rainfall of Porto Rico in a wet year, 1901. (Rainfall in inches; small italic figures give altitudes in feet.)

THE MECHANISM OF CYCLONES.

By F. J. W. WHIPPLE.

[*Abstract reprinted from* Report of the 85th Meeting of the British Association for the Advancement of Science, Manchester, 1915. p. 367.]

The distribution of pressure and temperature in cyclones in the Temperate Zone has been learned from the analysis of the records from the meteorographs carried by [sounding] balloons. Up to a height of 8 or 9 kilometers the cyclone is composed of air cooler than its surroundings; at greater heights, i. e., in the stratosphere, the cyclone contains comparatively warm air. The lower limit of the stratosphere is depressed in the cyclone. This temperature distribution indicates that the air constituting the lower part of the cyclone has recently ascended, whereas the upper air has recently fallen, and accordingly the arrival of a cyclone is marked by an outflow of air at the bottom of the stratosphere and an inflow below. At the beginning of the present paper the amount of this displacement of air is estimated on the assumption that there is no direct exchange of heat, and it is shown that the outflow is concentrated between the 7th and 10th kilometers and is about 6.5 times the net loss of air as estimated by the fall of pressure at the earth's surface.

It is pointed out that a cyclone may be regarded as a disturbance in the stream of air which flows from west to east in the Temperate Zone, and the form of the isobars obtained by superimposing the permanent pressure distribution and the temporary cyclonic distribution is discussed. It is shown that when due allowance is made for the curvature and the progressive motion of these isobars, the gradient wind at certain heights is much less than it would have been if the curvature were inappreciable, so that at these heights the air supply from the rear to the front of the cyclone fails and the cyclone appears to move under the influence of suction applied at the base of the stratosphere. The explanation may be summarized as follows:

If the flow of air at any level were entirely horizontal and along the isobars, and if the changes of density were negligible, then the condition for continuity would require the velocity to be inversely proportional to the distance between the isobars, i. e., the velocity would be directly proportional to the pressure gradient. This condition is not satisfied, however, in regions where the air trajectories are curved. The pressure has to produce the centripetal acceleration in the curved path in addition to overcoming the tendency to turn to the right, which is the feature of all horizontal motion in our hemisphere. Accordingly the actual velocity where the isobars are curved is less than it should be to secure continuity and maintain a stationary distribution of pressure. The effect of curvature in reducing the velocity is greatest at the heights where the winds are strongest, and therefore the suction effect is concentrated near the base of the stratosphere.

The general argument is supported by the analysis of two special cases.

55120—16——2

CAUSES CONTRIBUTORY TO THE ANNUAL VARIATION OF LATITUDE.[1]

By HAROLD JEFFREYS.

[Abstract.]

The motion of the terrestrial pole relative to the surface of the earth was shown by Chandler to consist mainly of two parts, viz, a circular motion with a period of 430 days, and an annual motion in an ellipse. The former is considered to be identical with the free vibration called the polhode motion, or Eulerian nutation. The latter is generally attributed to meteorological causes. An elaborate analysis of these causes is published by Mr. H. Jeffreys in the "Monthly Notices." The author examines separately the effects of atmospheric motion, oceanic movements, precipitation, vegetation, and polar ice. He concludes that "the known meteorological causes are apparently capable of giving a fairly good account of the observed annual motion of the pole, the errors found being perhaps within the range of uncertainty of the data."

[1] See Monthly notices, Roy. astron. soc., London, April, 1916, 76: 499-525. Pl. 8.

METEOROLOGICAL ASPECTS OF OCEANOGRAPHY.

By Dr. HANS PETTERSSON.

[Dated: Oceanografiska Institutionen, University of Gothenburg, May, 1916. Received June 12, 1916.]

For many centuries oceanographical investigations were carried on for purely practical, viz, nautical purposes only. Practically all we know of the bathymetrical features of the shallower parts of the ocean is based on soundings taken for practical reasons. The same applies to our knowledge of tidal phenomena which has culminated in modern tidal predictions, a field where science applied to practical purposes has scored one of its most brilliant successes.

The vast systems of currents which traverse the surface of the oceans have become known to us mainly through unnumbered observations by ocean-going merchant vessels; observations which were for the first time thoroughly investigated and made useful to man by the classical work of the distinguished American scientist, Maury, the father of oceanography.

During the last 20 or 30 years a new practical reason for marine research has arisen, namely, the rapidly increasing importance of the fishing industry. Since the introduction of steam trawlers the high-sea fisheries in various important areas have become so intensified that disquieting results of overfishing are plainly visible. The necessity of safeguarding against this evil was one of the main motives which led to the establishment of an international organization for the study of the sea which, for more than 12 years, had vigorously pursued systematic investigations of the propagation, growth, and migrations of the most valuable food fishes as well as their dependence on the variable physical and chemical properties of the sea water. A definite proposal for international legislative measures against excessive fishing of immature fishes had already been put forward by this organization when the outbreak of the present war brought its work to a temporary standstill.

Besides these two practical motives for systematic investigations of the ocean there is a third reason for increasing and perfecting our present knowledge of the sea, a reason which will no doubt become more generally acknowledged in the near future. I refer to the all-important influence which the ocean exercises over the climate and the weather of the surrounding continents. The object of the present paper is to give a brief survey of the most prominent ways in which this influence becomes manifest.

INFLUENCE OF THE OCEAN ON AIR TEMPERATURES.

From a thermal point of view the function of the ocean is twofold. It accumulates solar heat and redistributes it more evenly both in *time* and in *space*. Its power to do so is derived mainly from two physical properties of water, viz, its large heat capacity (1 cubic meter of water on cooling 1° C. will raise the temperature of 3,000 cubic meters of air by the same amount) and its mobility. The mobility of the water in the vertical dimension assists in carrying out the first of the two functions before mentioned, while its mobility in the horizontal plane enables the ocean to exert its second thermo-regulating function, i. e., by means of its large warm and cold surface currents.

As regards the capacity of the ocean to distribute heat of solar origin more evenly in time—to act as a kind of "savings bank" for solar energy, receiving deposits in seasons of excessive insolation and paying them back in seasons of want—we can get a faint idea of the state of things which would prevail were the earth devoid of its oceans by comparing the climate of central Eurasia with that of Scandinavia or the British Isles. The following figures, which give the number of heat units (kg.-cal.) passing in and out through 1 square meter of different surfaces per annum, are also very illuminating.

Number of heat units (kg.-cal.) passing in and out through 1 square meter of different surfaces annually.

	Kg.-cal.
Sandy soil in a forest	13,000
Sandy soil under grass	18,500
A fresh-water lake (down to 24 meters)	280,000
Southern Baltic (down to 55 meters)	520,000

Not less important is the second function of the ocean, viz, that of distributing its store of heat (accumulated chiefly in the Tropics) more evenly over the surface of the globe. The profound manner in which the ocean modifies the temperature conditions of our planet is perhaps best demonstrated by a chart showing the isotherms (yearly averages) of the North Atlantic surface waters, specially their abnormal trend to the north in its northeastern part where the sea's isotherm of 0°C. runs beyond the 80th parallel, i. e., some 10° farther than its average latitude for the Northern Hemisphere, and where the air temperature anomaly in January for certain areas off the Norwegian coast shows positive values of *not less than* +27°C. To return to our metaphor: The savings bank for solar heat which we call the ocean has a very extensive "foreign exchange."

So far these facts are of course generally acknowledged. Important as the temperature-regulating functions of the ocean undoubtedly are, they would afford but little actual interest were they always, from year to year, exercised in exactly the same manner and with unvarying intensity. However, there is ample evidence to show that this is not the case. Or, metaphorically, the annual "dividends" paid by this bank to its "shareholders," i. e., the continents round its borders, are emitted on a variable scale.

There are years when the heat supply runs down to famine values, and other years of lavish abundance. Exact proofs of this fact were first produced 20 years ago in a paper by Otto Pettersson,[1] which may be said to open new perspectives on the relationship between oceanography and meteorology. By means of curves extending over many years it was shown that the surface temperatures of the Atlantic off the coast of Norway in winter (monthly averages for January and February) vary considerably from year to year, and that these variations are reflected on a magnified scale in perfectly parallel fluctuations of the air temperature over central Sweden. Further, it was shown that the same parallelism is revealed in various important phenomena in nature, such as the disappearance of the snow cover, the development of vegetation (flowering of certain spring herbs), and also in the thawing of the soil (marked by the commencement of plowing).

A curve (fig. 1) showing the latter relationship is reproduced here from Pettersson's paper.[1] To put the matter more explicitly, the date on which agricultural spring work can begin, which is of very great importance for the subsequent development of the crop, is determined by oceanographical conditions *which prevail two to three months earlier.*

[1] *Pettersson, Otto.* Ueber die Beziehungen zwischen hydrographischen and meteorologischen Phänomenen. Meteorolog. Ztschr., Aug., 1896, 13: 285 and 316, fig. 14.

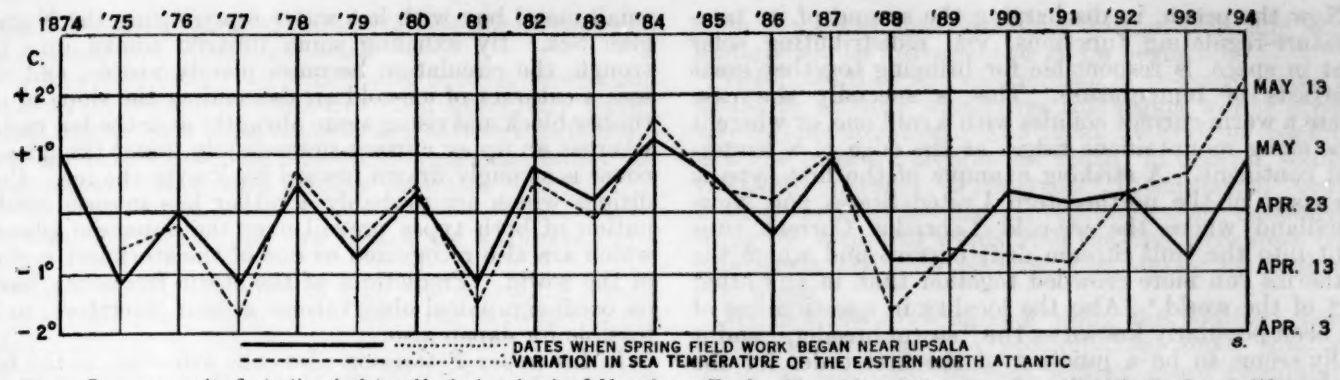


FIG. 1.—Curves comparing fluctuations in dates of beginning of spring field work near Upsala, with variations in the temperature of the Atlantic off coast of Norway.

A number of other investigators, such as Meinardus and Hildebrandsson, have taken up work along the lines pointed out by Otto Pettersson and have clearly proved the surprising extent to which dominant meteorological features of Europe are governed by the prevailing state of the surface sheet of the North Atlantic. So far, however, hardly any practical benefit has been derived from these discoveries.

The efforts of modern meteorologists seem to be almost exclusively directed toward the attainment of *short-range* forecasts, viz, the prediction of the probable weather which will prevail a couple of days later. The greatest living authority on dynamical meteorology, V. Bjerknes, is reported to have said that the problem of foretelling the weather three days in advance from a sufficiently detailed knowledge of the meteorological elements over a certain area is completely solved. Only the intricate calculations required for a solution in the individual case will keep a staff of trained assistants busy for several weeks!

The importance of successful short-range forecasts of course must not be underestimated. Apart from its value for other open-air activities, it may become eminently useful to agriculture, specially at harvest time; while their value for the fishing and shipping industries, in the shape of storm warnings, has been established beyond dispute. This is particularly the case in Sweden where these predictions have proved eminently successful owing to the excellent work of Dr. Nils Ekholm.

However, it would appear that still greater practical benefit might be reaped from long-range forecasts defining the average character of a coming season, such predictions as Pettersson proclaimed to be possible in his paper before mentioned. Growing crops worth millions of dollars may be more or less ruined by a cold spring, a hot and dry summer, or a wet autumn, and an early warning of such prospects would have a value which can hardly be overestimated. Besides trying to predict the extremely variable state of the fickle atmosphere one should give more attention to the *conservative element* in meteorology, viz, the surface sheet of the ocean where changes may be observed months before their effect on our weather becomes manifest.

Unfortunately our present lamentable lack of knowledge of this marine element makes it practically impossible now to give similar forecasts of any value. It is therefore a most welcome symptom that the meteorological services of several countries have of late started to issue monthly charts giving the actual state of the surface of the North Atlantic (or rather of those parts which lie along the principal ship routes) and also to work up portions of the immense material contained in the log books of the ocean-going merchant vessels. Pioneer work of this kind has already been completed by Nansen and Helland-Hansen whose results, as yet unpublished, prove that unmistakable changes in the surface temperature of the North Atlantic occur from year to year and that these changes *run parallel over vast areas*, if not over the whole ocean.

Finally the International Council for the Study of the Sea, at Copenhagen, are employing the leisure due to the temporary interruption of their regular research by the war, by taking up this kind of work on a still broader scale, viz, the average hydrographical conditions of certain representative areas for the period 1900–1913, as well as the departures from these values for each month of the same time. In this work the excellent observations extending over some 40 years compiled by the Danish Meteorological Office have proved particularly valuable.

It is earnestly to be hoped that when the end of the present state of war makes a return to sane occupations possible, the International Council may be able to extend its carefully worked-out methods and experience of organized scientific work on practical problems, to the larger field of the North Atlantic Ocean.

With regard to long-range forecasts of the kind indicated in this paper the most important part of the whole North Atlantic are the coastal waters of the eastern United States, specially the Strait of Florida. By means of a few recording current meters—to be described in a succeeding paper—combined with thermographs a close watch might be kept at comparatively low cost over this pulse of the Gulf Stream. A sensible departure from the average value of the vast amount of stored heat carried through this strait (some 10^{12} heat units per hour if the water were to be cooled only to +10° C.) might have profound effects on the weather of the following months both on the European and the North American continents. Similar observations off the coasts of Formosa would no doubt be of corresponding value for predicting the weather of Japan.

INFLUENCE OF THE OCEAN ON ATMOSPHERIC CIRCULATION.

It is quite easy to prove that if the temperature were and remained uniform all over the surface of our planet there would be no atmospheric circulation whatever; a perpetual dead calm would reign supreme. On the other hand, it is also evident that the more rapidly the temperature varies along the earth's surface at a certain locality the more intense, in general, will be the atmospheric disturbances set up there. Therefore, wherever great contrasts of temperature prevail within short distances, the locality will be distinguished by the large number of atmospheric disturbances which either originate there or are stimulated by it.

Now the ocean, in discharging the second of its temperature-regulating functions, viz, redistributing solar heat in space, is responsible for bringing together great contrasts of temperature. This is specially the case where a warm current collides with a cold one, or where it runs along mountainous ridges at the edge of a winter-cold continent. A striking example of the first type is the coast of the northeastern United States and Newfoundland where the ice-cold Labrador Current runs right into the Gulf Stream drift current and where the isotherms run more crowded together than in any other part of the world.[2] Also the locality in question has of old been popularly known as the "storm breeder," and it really seems to be a junction of the first order for the tracks of transcontinental cyclones coming from the west. If the intensity of the temperature contrasts for this area, i. e., the strength of the temperature gradient along the surface, were known for a number of years it might show a pronounced parallelism with simultaneous changes in the storm-frequency curve for the surrounding parts of the ocean.[3]

An example of the second type is afforded by the region off the coast of northwestern Scandinavia, where in January the aforesaid temperature anomaly of +27° C. prevails. The effect on the atmospheric circulation is also most striking, as has been proved through recent studies by J. W. Sandström, the eminent Swedish meteorologist. Having set himself the task of discovering by what kind of atmospheric mechanism the Norwegian Sea does exert over the Scandinavian climate that influence discovered by O. Pettersson, Sandström[4] made prolonged explorations in the Scandinavian Alps during midwinter and at considerable personal risks. He then found that the prevailing easterly winds, once they get over the highest ridges, will descend along the slopes to the sea, gaining impetus from the high density of the air (which is increased by the mass of snow it carries along with it) so that the air finally rushes like an ice-cold cataract at a terrific pace downward to the warm sea surface. There its temperature and amount of moisture are increased and some of the re-warmed air returns toward the European Continent as a westerly wind at a higher altitude. The boundary surface between the warm and moist upper current from the sea and the ice-cold lower current of opposite direction fluctuates considerably up and down, the west wind sometimes reaching as far down as to the mountain slopes, where the east wind is temporarily dammed up. However, when the east wind again breaks loose it descends with a redoubled violence. The wind velocity at the coast of Norway therefore sometimes increases from a gentle breeze to a gale of 30 meters per second (108 km. per hour) in the course of a few minutes, which may of course involve considerable loss of life and property to the fishing population. Storm warnings based on these discoveries by Sandström will shortly be issued by the Norwegian authorities.

The atmospheric circulation described here can be beautifully demonstrated in a trough with walls of plate glass such as I have used for hydrodynamical experiments (length 100 cm.; width 30 cm.; depth 22 cm.). The trough is divided transversely by a triangular block of rubber reaching halfway up its sides. One partition is filled with ice, and on the bottom of the other is placed a small metal box with hot water representing the Norwegian Sea. By exhaling some tobacco smoke into the trough, the circulation becomes plainly visible, and one sees a cataract of ice-cold air descending the slope of the rubber block and rising again abruptly over the hot metal, whereas an upper current immediately under the [glass?] cover is strongly drawn inward back over the ice. Conditions which are probably a rather less intense combination of both types prevail over the Japanese islands, which are also recognized as one of the stormiest regions of the world. Predictions of the storm frequency based on oceanographical observations appear, therefore, to be feasible for Japan also.

In his paper Pettersson also calls attention to the fact recognized already in 1879 by the Danish meteorologist, Hoffmeyer (Ztschr. d. Oesterr. Ges. f. Meteorol., 1878, **13**, and 1879, **14**), namely, that the distribution of the air pressure shows distinct effects of oceanic influences. Especially in the cold season is there a tendency for stationary barometric minima to develop and to remain stationary over water surfaces, as the latter are then in general considerably warmer than the surrounding land surfaces. A chart of the average isobars for the winter months plainly shows how closely these follow the outlines of the continents. These regions of relatively low pressure are of considerable importance in our latitudes on account of their evident close relation to the movements of the traveling barometric depressions, i. e., the cyclones. Maps of the principal storm tracks, such as those by van Bebber (see fig. 2), also show that regions like the North Sea with the Skagerrack, the southern Baltic—in a less degree even large lakes like Vännern (Sweden) and Ladoga (Russia) as long as they remain unfrozen—are touched by the most frequented storm tracks. A close and continuous study of the surface winter temperatures of these regions therefore ought to be useful for the drawing up also of short-range weather forecasts.

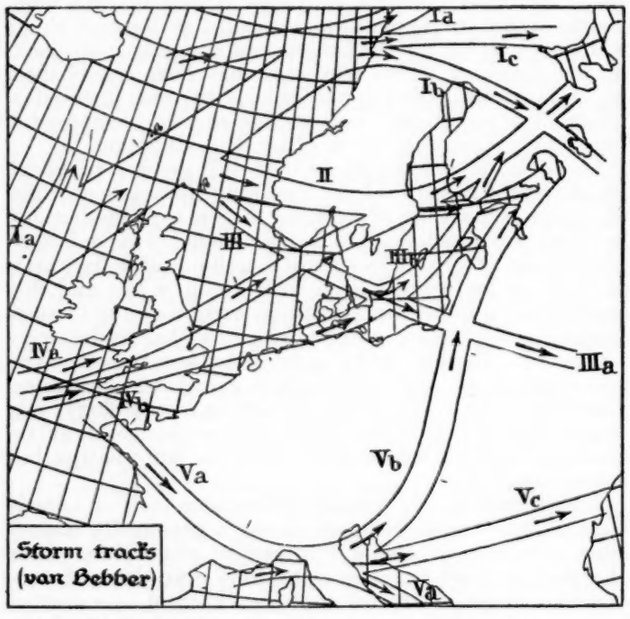


FIG. 2.—Storm tracks for northwestern Europe, after van Bebber.

The immense importance for our winter climate, of the large low-pressure region which prevails in winter over the warm ocean surface to the south of Iceland, was also pointed out by Hoffmeyer and has been the subject of

[2] This important area, which was studied already by the Challenger expedition, by Sigsbee, and others, has been investigated quite recently by the famous Norwegian fishery authority, Dr. John Hjort, at the request of the Canadian Government, with highly interesting results.

[3] The suggestions in this paragraph should be regarded as such. It remains to be proved that this junction of marine currents actually gives rise to cyclones. Most of those tracked originated somewhere far west of there.—C. A., jr.

[4] *See* his contributions to this REVIEW and to the Bulletin of the Mount Weather Observatory.—C. A., jr.

more recent remarkable studies by Teisserenc de Bort and his collaborator, Hildebrandsson.[5]

In fact the extent to which atmospheric circulation depends on oceanic conditions, when once fully recognized, will make a close cooperation between meteorologists and oceanographers a condition sine qua non for the formulation of successful weather forecasts.

THE INFLUENCE OF THE OCEAN ON RAINFALL.

From a theoretical point of view the prevailing conditions of the surface sheet of the ocean ought to have a decided influence on the amount of rain precipitated over the continents. However, so far no very definite proofs have been produced for the actual existence of the supposed relationship. The greatest part of the rain which falls over Europe is no doubt formed by evaporation from the surface of the North Atlantic. Now the rate of evaporation, which is a function of several variables, varies rapidly with temperature, a rise of 5 degrees from +10°C. to +15°C. corresponding to an increase in the vapor pressure of some 40 per cent. It would therefore appear very likely that an unusually low surface temperature over large parts of the North Atlantic may be followed by a reduced rainfall in a coming season. O. Pettersson[6] has proved that at times when an outburst of icebergs takes place in the South Indian Ocean the monsoon rains over India will, in general, be very scanty, which inevitably results in a more or less complete failure of the crops and subsequent famine among millions of human beings. The greatest outburst of icebergs in the South Indian Ocean occurred in 1895–1897, and 1896 was a year of exceptional drought in India; the crops there failed over several hundred thousand square miles and millions of the population were reduced to a state of famine.

Once we have full knowledge of the surface temperature (and the salinity) of the most representative parts of the North Atlantic Ocean, and can follow their variations from month to month, perhaps a kind of long-range forecast of the rainfall also may become feasible.

I have tried to point out that from the standpoint of the meteorologist a systematic and regular observation of the North Atlantic is a task which ought to be undertaken without delay and that it would have every prospect of gaining results of immense practical value to mankind.

In a succeeding paper I intend to give brief descriptions of some novel instruments and methods which make it possible to take isolated or continuous observations of various oceanographical elements with a minimum of labor and a high degree of accuracy.

PRECIPITATION OVER THE SOUTHEAST ROCKY MOUNTAIN SLOPE.[1]

By CLEVE HALLENBECK, Assistant Observer.

[Dated: Weather Bureau, Roswell, N. Mex., June 14, 1916.]

Nearly all of the general rains over the region embracing eastern New Mexico and the extreme western portion of Texas come with easterly winds. The greatest frequency of precipitation at the eastern border of this area is with southeast winds, gradually shifting to northeasterly by the time the Pecos Valley in New Mexico is reached. It can be said that in this region rains coming from any other directions than southeasterly and northeasterly are so infrequent as to be negligible.

It follows that any distribution of pressure giving rise to steady easterly winds over this region will be productive of precipitation. The most dependable condition is a low pressure area to the south; in general, south of the 35th parallel of latitude. Precipitation usually begins when the low has moved far enough eastward to bring the incurving winds from the Gulf over west Texas as easterly and over eastern New Mexico as northeasterly winds.

While these lows moving along the southern border nearly always produce precipitation, those that pass north of the 35th parallel seldom cause precipitation over this area. This is due to the topography of the Southwest. The Continental Divide, extending southward from Colorado, divides in northern New Mexico into two branches; the west branch extends southwestward nearly to the corner of the State, while the east branch extends southward, separating the Grande and the Pecos Valleys. The Divide has an elevation of 10,000 to 12,000 feet in the northern part of the State; through the central and southern portions of the State the two branches have about the same elevation of 8,000 feet. The eastern branch, however, extends down into Texas to the meeting of the Grande and Pecos, and thus becomes a controlling factor in the distribution of precipitation over this area. That part of Texas lying immediately east of this range is the dryest portion of the State.

Westerly winds over Arizona and New Mexico are "upslope" winds until they reach the western branch of the divide, then their direction averages about horizontal until they pass the crest of the eastern branch, after which they are "downslope" as long as their direction has an eastward component.

Taking now the case of a depression centered near the northern border of the State: over its western quadrant, the winds are generally "upslope," and therefore favorable to precipitation. Also over its southeastern quadrant the wind is moving "upslope" from the Gulf. But over that portion of its southern quadrant lying east of the divide and west of the belt of southeasterly winds from the Gulf is the area embracing eastern New Mexico and extreme western Texas, where the wind is blowing "downslope," and therefore is unfavorable to precipitation. For this reason, a storm area passing eastward approximately along the northern border of the State causes general precipitation over all the area under its influence, with the exception of this "dry belt."

The accompanying chart (fig. 1, XLIV–72) shows an ideal wind circulation around one of these depressions. The precipitation areas of many LOWS show remarkable conformity to this theoretical one.

A large number of the southern LOWS are southern centers of low troughs. But even in depressions that are regularly formed, there seems to be a strong tendency of the Gulf winds to blow in from the southeast, often blowing in a straight line, or even recurving slightly to the north, when the low center is located as shown on the theoretical circulation. On the chart presented this tendency is emphasized to show the wind-shift line, which normally marks the western limit of precipitation.

The distribution of precipitation around a depression is illustrated in the four composite maps presented in figures 2, 3, 4, 5. These were constructed from the average data for a number of LOWS in approximately the same positions, and show the average pressure, wind direction, and precipitation frequency for LOWS cen-

[5] *See* their work "Centres d'action de l'atmosphère."
[6] Svenska Hydrografisk-Biologiska Kommissionens Skrifter, V.
[1] Accompanied by Charts XLIV–72 to XLIV–76. Figures 1 to 9.

tered near the northwest, northeast, southeast, and southwest corners of the State. It will be seen that the movement of a storm approximately along the northern border seldom produces precipitation over the "dry belt," while those that move along the southern border seldom fail to produce precipitation over the same area.

Of 16 LOWS that crossed the 105th meridian south of latitude 35°, 14 or 88 per cent produced precipitation over this region, while of 21 LOWS that crossed the 105th meridian between latitudes 35° and 40°, only 3 or 14 per cent produced precipitation over the "dry belt."

The late winter and early spring of 1912 furnished an unusually large number of the latter type of LOWS, there being no less than 10 of them within a three-months' period, all of which failed to cause precipitation over the region under discussion.

As illustrations, attention is invited to the weather maps of the following dates in the year 1912: February 20 and 24–25, March 2–5, 10–12, 13–14, and 20–24, April 19–20 and 27–28, and May 10–11. The storms of these dates caused general precipitation over their southeast and southwest, but missed the southern portion of the east mountain slope altogether.

One of these, the storm of March 11–12, is reproduced in connection with this discussion (fig. 6). It shows clearly this peculiarity in the precipitation area. A similar condition is illustrated in the combined maps of February 12–13, 1915 (fig. 7). With both of these storms the dry area extended northward into Colorado, but it was usually the case among the numerous types studied, that the dry area was somewhat more limited than this. The composite maps of the storms moving north of parallel 35 illustrate fairly well the average frequency of precipitation over this area and over the contiguous regions to the east, north, and west.

The combined maps of February 24–25, 1912 (fig. 8), give an example of a LOW being forced southeastward across New Mexico by incoming high pressure over the north, and producing general precipitation over the "dry belt," which would not have occurred had the LOW moved normally eastward. Compare the first position of this LOW (black of fig. 8) with the composite map of LOWS in that position (fig. 2); also with the LOWS of March 11, 1912 (black of fig. 6), and February 12, 1915 (black of fig. 7.)

Therefore the following general rule, applying only to the area under discussion, may be stated: *A storm area passing over or near New Mexico does not usually cause precipitation south of its center.*

Another condition that frequently produces precipitation over this region is a high-pressure area moving southeastward to Kansas or Oklahoma, preceded by southeast or east winds over this locality. The precipitation is generally light, and probably would not be of importance were it not for the fact that it occurs when conditions are strongly indicative of fair weather. When the incoming high-pressure area causes a large fall in temperature, precipitation may occur when the preceding humidity conditions are no more than normal. But usually it requires a preceding southeast or east wind, which seldom fails to increase the humidity over the region in question. Many such HIGHS cause overcast skies over southeastern New Mexico even when precipitation is absent.

A composite map of fourteen HIGHS, with their attendant precipitation areas, is here presented (fig. 9). In constructing this map, only such HIGHS as caused precipitation in western Texas or southeastern New Mexico were used. HIGHS of this class often bring about local rain in southeastern New Mexico when the skies are clear over the contiguous regions.

FOG IN RELATION TO WIND DIRECTION ON MOUNT TAMALPAIS, CAL.

By HERBERT H. WRIGHT, Assistant Observer.

[Dated: Weather Bureau, Mount Tamalpais, Cal., Feb. 15, 1916.]

The summit of Mount Tamalpais, rising to 2,600 feet above the Pacific Ocean within a distance of about 8 miles from the shore, possesses a distinct advantage for observational purposes over many other places that far exceed it in height. Owing to its proximity to so large a water surface it is specially suitable for observing and studying fog.[1]

Fog may be defined as visible particles of moisture floating in the atmosphere. In the vicinity of Mount Tamalpais fog usually occurs at an altitude of from 500 to 1,000 feet. It is therefore plainly visible from the Weather Bureau observatory near the summit of the mountain.

While fog occurs oftener and prevails for longer periods of time during the summer months, it occurs to some extent at all seasons. Table 1, compiled from records by the Weather Bureau on Mount Tamalpais, for the six years, 1910 to 1915, inclusive, shows the number of days in each month on which fog was observed in varying amounts below the elevation of the station. It will be seen from this table that the greatest percentage of fog occurs during the summer season.

TABLE 1.—*The number of days in each month on which fog was observed below the Weather Bureau station on Mount Tamalpais, Cal., 1910–1915, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days	Days.
1910	5	7	16	19	20	27	28	30	23	16	14	6	211
1911	0	4	7	13	9	26	29	27	19	11	11	6	162
1912	4	8	5	4	16	13	27	26	14	6	6	7	136
1913	5	10	14	16	22	25	27	25	17	16	10	12	199
1914	7	0	10	10	24	25	30	29	19	14	8	6	182
1915	5	2	6	11	18	25	26	26	20	20	12	7	178
Sums	**26**	**31**	**58**	**73**	**109**	**141**	**167**	**163**	**112**	**83**	**61**	**44**	**1,068**
Means	4.3	5.2	9.7	12.2	18.2	23.5	27.8	27.2	18.7	13.8	10.2	7.3	178

When a mass of air has been cooled to its dewpoint or lower, some of its invisible moisture condenses to form a visible cloud or fog. One of the various ways in which this cooling may be accomplished is that of the mixing of masses of air having different temperatures and relative humidities. In this process the character and the direction of the wind play a very important part. Entirely different conditions result when the warm air is driven out over the water to meet the cool air there than when the cool, moist air is carried shoreward, there to mix with the warmer air over the land. Mere direction alone, however, does not determine this; the character of the wind must also be considered. Fog very seldom forms when the wind is blowing from the east.

These east or northeast winds are not common along this coast, and occur only when a well-developed area of high pressure overlies Nevada and adjacent States. In the summer the air over the semiarid regions of Nevada and Utah becomes exceedingly warm and dry. Owing to the barometric gradient this warm, dry air flows down over California, and owing to the adiabatic heating often reaches the coast even warmer than when it started. Thus this air, under the influence of the east wind, goes out to mix with the cool air over the ocean, and being so dry has an enormous capacity for water vapor. The resultant temperature of the mixture is not low enough

[1] See the papers by *McAdie*, beautifully illustrated, in this REVIEW for 1900, 28: 283–6; 492–3; and 1901, 29: 24–5; 61–3; 104–6; and Weather Bureau bulletin "L".—C. A. jr.

to produce saturation and no fog appears. This is true during the winter season as well as the warmer part of the year. An anticyclone over Nevada in winter usually results in clear, cold weather for California, in contrast to the warming effect experienced in summer under a similar distribution of pressure. While these northeasterly winds are extremely cold, they are as a rule quite free from moisture and are able to absorb considerable water vapor before becoming saturated, but of course not to the extent that we find in summer when the air is both dry and warm.

Table 2 gives an idea of the difference in temperature and relative humidity during the summer between the land air and the air over the ocean. Point Reyes Light, 22 miles northwest of Mount Tamalpais, is on a point of land extending half a mile or more into the Pacific, and the Weather Bureau station there is on a bluff only 490 feet above sealevel. The record for Mount Tamalpais was made at an elevation of approximately half a mile (H=2,375 feet).

The facts (*a*) that the specific heat of water is large, (*b*) that clear water is deeply penetrated by solar radiation, and (*c*) that much of the heat absorbed is consumed by evaporation, combine to keep water temperatures from rising very high. Hence both radiation by the water and heat conduction from it are kept correspondingly low. The land, on the other hand, is rapidly heated and almost as rapidly warms the lower layers of air by radiation and conduction. Then by subsequent convection the air is heated to a considerable altitude. It has been observed that fog is more likely to occur when the temperature above is higher than at sealevel. Also that fog probability varies directly as the difference in temperature between the lower and upper air layers increases.

TABLE 2.—*Comparison of daily temperatures and relative humidities at Mount Tamalpais and at Point Reyes Light, Cal., during August, 1914.*

Date.	Temperatures.						Mean relative humidity.	
	Maximum.		Minimum.		Mean.			
	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.
	°F.	°F.	°F.	°F.	°F.	°F.	P. ct.	P. ct.
1	91	66	74	49	82	58	26	85
2	80	55	49	48	64	52	23	95
3	72	65	48	54	60	60	78	84
4	83	55	65	49	74	52	33	99
5	90	55	72	50	81	52	30	86
6	82	59	71	50	76	54	22	80
7	83	57	66	50	74	54	24	81
8	67	57	53	52	60	54	62	96
9	71	58	51	53	61	56	42	96
10	76	57	66	52	71	54	51	92
11	86	58	70	51	78	54	27	92
12	79	57	69	52	74	54	20	91
13	77	58	67	52	72	55	26	91
14	80	60	71	52	76	56	42	85
15	82	59	73	53	78	56	16	84
16	83	58	72	50	78	54	14	78
17	81	57	65	50	73	54	30	80
18	72	54	60	48	66	51	36	92
19	62	58	46	51	54	54	60	91
20	72	58	57	49	64	54	47	85
21	79	56	62	49	70	52	38	100
22	82	55	72	49	77	52	32	94
23	80	55	68	49	74	52	34	91
24	70	56	46	50	58	53	34	94
25	69	55	58	49	64	52	34	95
26	67	55	45	50	56	52	37	95
27	73	53	60	50	66	52	59	98
28	77	53	55	50	66	52	51	100
29	76	54	65	49	70	52	40	94
30	68	53	48	49	58	51	68	100
31	54	56	45	50	50	53	87	93
Mean	76	57	61	50	69	54	39	91

The greatest differences in temperature and relative humidity between the masses of air in question are to be found during the summer season. Owing to the shortness of the days in winter, the land surfaces can not absorb as much heat as they radiate into space during the long nights. This, together with the fact that the sun is so far south of the Equator, causing a small angle of incidence to the rays received, does not permit the warming of the air over the land to any great height. In fact, the ocean air is now warmer than the air over the land, as will be seen by referring to Table 3.

During the summer, when the air over the ocean is cooler than that over the land in the vicinity of Mount Tamalpais, the prevailing west wind produces a mixing of air masses differing greatly in temperature. Fog then forms when the resulting temperature is at the dewpoint of the air mass or lower. Thus the wind direction, and consequently its character, which is determined by the direction, are great factors in the production of fog. From May to September the familiar land- and sea-breeze prevails. By referring again to Table 1 it will be observed that it is during this period that fog is most frequent. The sea-breeze begins early in the forenoon and with it comes the fog. It often lasts well into the night. The land breeze is the weaker of the two and sometimes fails altogether. It is then too weak to reverse the action of the sea-breeze and little if any fog is dissipated during the night. The popular impression is that the wind "goes down" late in the evening and the land breeze, being so weak, is not felt.

TABLE 3.—*Comparison of daily temperatures and relative humidities at Mount Tamalpais and at Point Reyes Light, Cal., during January, 1916.*

Date.	Temperatures.						Mean relative humidity.	
	Maximum.		Minimum.		Mean.			
	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.	Mount Tamalpais.	Point Reyes.
	°F.	°F.	°F.	°F.	°F.	°F.	P. ct.	P. ct.
1	38	49	30	42	34	46	100	86
2	47	52	36	42	42	47	100	100
3	43	52	37	44	40	48	100	92
4	42	54	35	41	38	48	100	97
5	39	51	34	44	36	48	100	89
6	40	52	35	42	38	47	93	85
7	41	50	38	44	40	47	100	90
8	42	50	37	44	40	47	100	95
9	39	51	32	41	36	46	99	100
10	33	45	29	35	31	40	93	77
11	37	47	30	42	34	44	74	76
12	40	46	32	40	36	43	92	100
13	43	46	38	43	40	44	100	100
14	43	48	32	42	38	45	98	85
15	38	50	32	41	35	46	99	90
16	44	50	36	43	40	46	92	82
17	43	50	34	43	38	46	98	72
18	35	47	32	40	34	44	92	93
19	39	48	32	40	36	44	96	92
20	39	51	32	42	36	46	90	91
21	38	49	34	42	36	46	98	94
22	46	49	38	42	42	46	100	100
23	47	52	44	45	46	48	100	100
24	46	54	44	49	45	50	100	100
25	46	50	32	44	39	47	92	80
26	34	46	28	40	31	43	60	79
27	39	48	27	36	33	42	100	98
28	32	45	27	35	30	40	91	94
29	32	44	27	35	30	40	92	91
30	36	47	27	37	32	42	92	78
31	40	52	30	37	35	44	64	76
Mean	40	49	33	41	37	45	94	90

In observing the formation of fog from Mount Tamalpais it has been noticed that the fog often starts a short distance from the shore and then comes inland. Occa-

sionally the fog forms as far as 20 miles out at sea, increasing in amount as it comes steadily landward in the form of a high bank or wall. This formation is probably of different origin from that referred to in the preceding paragraphs. It is due no doubt to the upwelling of relatively cold water some distance offshore. The ocean air, already near the point of saturation, is cooled to its dewpoint when it comes in contact with this relatively cold water. The fog then formed persists unbroken for long periods of time. When the air in which this fog floats is drawn inland to replace the heated air rising over the hot interior valleys in summer, this fog, already formed, moves inland with it and does not dissipate until the sun literally dries it up from above. The wind direction naturally determines whether or not fog of this kind comes inland.

A marked case of fog formation and dissipation with relation to the shifting of the wind occurred in December, 1915. On the 20th the temperature on the mountain began to rise slowly. The following morning at 5 o'clock the thermometer recorded almost 1 degree higher than the preceding afternoon. Also considerable fog had formed below at an elevation of about 800 feet. By 5 p. m. the temperature had risen to 54°F., and conditions resembled those usually present during the summer months, the period of greatest fog prevalence below. Early the following morning the wind changed to the northeast, and by mid afternoon the fog had dissipated. At 5 a. m. the next day, December 22, it was observed that some fog had formed during the night. The temperature here was 53°F., while at San Francisco, 14 miles southeast of here, it was 50°F. The wind during the night and up to 7 o'clock in the morning was from the north, when it veered to the northeast. By 8:30 a. m. the fog below had disappeared. The temperature continued to rise, and reached 59°F. in the middle of the afternoon, and was 57°F. at 5 p. m. At San Francisco the temperature at 5 p. m. was 60°F., and had been as high as 64°F. in the middle of the day. No fog formed during that day. Soon after noon the wind backed to the northwest and continued from that quadrant until 9 a. m. of the 23d. At 5 o'clock that morning the temperature on the mountain, which represents the temperature of the upper air, was 56°F., equal to temperatures on many mornings in the middle of summer. At San Francisco the temperature at the same time was 51°F. About half the surrounding country was covered with fog. The wind swung to the northeast at 9 a. m., remaining there till 1 p. m., when it backed to the north. The fog cleared away before noon. The weather remained warm throughout the day, the wind continuing light from the north until 4 a. m. of December 24, when it veered to the northeast, remaining there until 11 a. m. Very little fog formed during the night. At 5 o'clock that morning the temperature here was 54°F., while at San Francisco it was 10 degrees lower. By 3 p. m. a fog bank could be seen about 20 miles out on the ocean, moving landward. Signs of the wind backing to the northwest were noticed at 3:30 p. m. By 5:30 it had gone to the northwest, and by 7 p. m. the direction was west. Also by 5 p. m. the fog had reached the shore and in another hour completely covered the ocean and land to the south and southeast of Mount Tamalpais. The temperature fell during the night of the 24th, being 49°F., at 5 a. m. of the 25th. At San Francisco it was 1 degree warmer. Simultaneously with the return to normal winter temperatures, i. e., warmer at sealevel than at higher altitudes, the fog began to dissipate and was gone by mid-afternoon.

The foregoing case bears out the hypothesis that the temperature of the upper air must be higher than that of the lower to produce proper conditions for fog formation, and also shows the part the direction of the wind plays with regard to fog formation and dissipation.

ON THE SO-CALLED CHANGE IN EUROPEAN CLIMATE DURING HISTORIC TIMES.[1]

By H. H. HILDEBRANDSSON.

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INTRODUCTION.

It is a well-established fact that climate has undergone very great changes in all the lands of the world during those distant times with which geologists are concerned. Even during the relatively short period that has elapsed since the end of the glacial epoch it has been possible to verify quite considerable variations in the Scandinavian countries. For example, it is well established that since the glacial epoch the climate of Sweden was at one time much warmer than it is to-day. In the peat-bogs have been found hazelnuts or filberts (*Corylus avellana*) as far as Lapland, the *Trapa natans* occurred in the lakes of Sweden up to the latitude of Upsala, and stumps of pine trees are found in the Scandinavian Alps up to the present limits of the birches, etc. These climatic variations are explained by the great changes in distribution of land and sea. It is clear that the climate must have been other than as it is at present when the Baltic occupied the greater portion of southern Sweden, and that it must have been different when this great lake was filled with fresh water than it was at the time when it formed a gulf of the sea filled with salt water. Archæologists find that the peninsula has had almost the same coast line—except the coasts of Norrland—since the beginning of the Iron Age, that is, at a period estimated as preceding our own by 2,500 years. Since that epoch there has been no notable change in the distribution of land and water. It remains to determine whether the climate has undergone a change during this period, i. e., historic times.

This question has been the subject of lively discussion for a long time and in recent years it has become somewhat acute, particularly through the recent researches of O. Pettersson. He seeks to prove that our climate undergoes a secular variation of about 18 centuries, due to a corresponding variation in the heat given out by the sun. This theory has called forth other researches concerning which we shall speak below.

Here I shall endeavor to present the results arrived at by a study of the question. We shall not consider accidental or periodic variations which are well recognized and exist everywhere. In every country there are years, even series of years, which are warm or cold, dry or moist, etc., and several more or less regular periods have been shown to exist, such as that of Brückner, that of solar spots and other shorter ones recently studied by Wallén. *In the present study we shall endeavor to determine whether or not there has been a continuous change in climate in one direction during historic times; in other words, whether the climate of Europe is improving or deteriorating.*

The question would be easily answered if we had continuous meteorological observations from several centuries back down to the present. But even the invention of meteorological instruments goes back scarcely

[1] *Translated from* Nova Acta Regiæ Societatis Scientiarum Upsaliensis, Series IV, v. 4, no. 5, Upsala, 1915. 31 p., 3 pl. 4°.—C. A., Jr.

two or three hundred years, and precise observations date from but the beginning of the last century.

Thus we can not have recourse to definite figures or to numerical observations. It is necessary to supplement direct observations by those passages in various authors' works relating to the condition of the crops, the time of the vintage, and a number of natural phenomena such as the freezing of the seas, opening of the rivers in the spring, the northern or southern limits of certain plants, etc.

TESTIMONY OF THE ANCIENTS.

At the outset one must consider what is to be found in this line for the southermost countries. Already Arago[2] had proved that *3,300 years have not brought about any appreciable alteration in the climate of Palestine*. In fact, in order that dates shall come to maturity, the mean annual temperature must be at least +21° C. On the other hand, the vine can not be profitably cultivated; it ceases to yield fruits suitable for the manufacture of wine as soon as this same mean temperature exceeds +22° C. Now, the lower thermometric limit for the date differs very little from the upper thermometric limit for the vine; if then we find that in two different epochs the date and the grape mature simultaneously at any given place, we may affirm that there has been no sensible climatic change during the interval between the two epochs. This is the case, however, in Palestine. The city of Jericho is called the city of palms. The Bible speaks of palms when referring to the earliest times. The Jews ate dates and prepared them as dried fruits; they also extracted from them a kind of honey and a fermented liquor. Pliny, Theophrastus, Tacitus, Josephus, Strabo, etc., also mention palms located in Palestine. *And the culture of the date has not ceased up to the present day.*

The same is true concerning the vine that one cultivated for the sake of wine. The Bible frequently mentions it and Strabo and Diodorus highly praise the vines of Judea. *The culture of the vine has not ceased.* The mean annual isotherm of 21°C. passes through Palestine as Arago predicted.

Arago's result has recently been confirmed in an unexpected manner. In the Mishnah, a collection of religious writings of the first century, they have found recorded measures of rainfall for the first century of our era. These are the first quantitative observations of a meteorological phenomenon which exist. The observations are in perfect accord with modern pluviometric observations at Jerusalem by Thomas Chaplin.[3] It is thus well established that the climate of Palestine has not changed during historic times.

Arago found the same circumstance to obtain for several places in the subtropical zone of the Mediterranean. According to Theophrastus the date palm was planted in Greece, but it bore no fruit there. However, on the Island of Cyprus the date attained to edibility although it did not wholly mature. The small amount of heat which this fruit lacks to-day in order to bring it to perfect maturity on that same island was therefore also lacking in antiquity.

Pliny says that the laurel and the myrtle grew on the Roman campagna. Now this would suppose a mean temperature of at least 13° or 14°C. These temperatures are the lower limits and [not] very far from the actual temperatures to-day. Pliny adds that in his time the laurel and myrtle prospered in middle Italy even up to some elevation on the mountain flanks. To-day these plants do not pass the altitude of 400 m., and from this relation we may conclude, without hesitation, that ancient Rome did not grow sensibly colder than Rome of to-day.

Was Rome warmer? "A passage from Pliny the Younger," says Arago, "leads to a negative reply. He said, in speaking of a field located in Tuscany, 'Laurels occur there; if they sometimes die there, this does not happen more frequently than in the environs of Rome.' Accordingly, at that time the laurels sometimes died in the environs of Rome just as happens to-day also." The temperature of that city can not have been much above that which causes the death of the laurel; that is to say, from 13°C. to 14°C. To-day the temperature of Rome is 15.5°C.

Varro gave the time of vintage as between September 21 and October 23; to-day one finds it on the average at October 2 in the vicinity of Rome.

Finally, Virgil and Pliny both state that the plant *Pinus picea* and the ordinary fir could not support the high temperatures of the plains and that they occurred only on the mountains, just as to-day.

Thus, it is evident *that the climate of Rome is sensibly the same at present as in the time of Christ.*

J. W. Gregory, J. Partsch, and others have proved in the same way that the climate south of the Mediterranean, in Cyrenicia and Tunisia, has not changed since Roman times. The character of the country and its vegetation remain the same as described by Strabo and other ancient authors.

But if the climate of the subtropical zone has not changed during historic times, one may deduce the following very important consequence: *If there has occurred a change in climate elsewhere, in more northern countries, one can scarcely explain this change by variation in the amount of heat given off by the sun.*

We remark that an increase in the amount of heat coming from the sun would not bring about a rise in temperature simultaneously over the whole surface of the earth. The tropical zone would first be the most strongly heated, consequently the evaporation from the ocean would be increased; but if the evaporation increased the rains would also increase. In the temperate and cold zones, however, a rainy season is also a season of low temperature. So, then, if the solar heat increases one will have a positive departure throughout the tropical zone and a negative departure over great expanses of the temperate and cold zones. On the contrary if the solar heat diminishes we need not expect a fall in temperature under the Tropics and a rise above the mean over extensive extratropical surfaces.

To study this question more closely we have calculated the mean temperature of January and of July for the 10 years 1894–1903, and the departures from these means for each year for a large number of stations distributed as well as possible over the earth's surface. We have entered all these departures on maps; the positive departures in red, the negative in black. Almost always the departures of the same sign cover very large areas, and the boundary line between the high and low temperatures ordinarily presents irregular sinuosities.

In Plate I [omitted] is reproduced the maps for July, 1902, and July, 1894. It is evident that in 1902 we have an example of the first case: Positive departures over almost all the tropical zone and negative areas on the north and south; while in 1894 the inverse relation obtains. *But in 1902–3 there was a minimum of sun spots, and in 1894–95 there was a maximum. Now a variation in the*

[2] *Arago.* Œuvres complete. Paris, 1858. t. 8.
[3] *Hellman, G.* The dawn of meteorology. Quarterly jour., Roy. meteorol. soc., London, Oct., 1908, 34: 226. Also published separately.

quantity of heat sent out by the sun makes itself felt particularly in low latitudes. If the climate has not changed, a change in more northern countries can not be explained by a variation in the heat emitted by the sun.[4]

Arago thought that the southward retrogression of the limit of cultivation for the vine in France and England appeared to show that even in the sixteenth century the summers had grown warmer than they are to-day. He adds, however, "I do not attach more importance than it deserves to this latter circumstance. The quality of the wine depends, indeed, too much on the nature of the plant and the care given by the cultivator to permit that it should furnish unanswerable arguments in the question of the change of climate."

This question was the object of a lively discussion at the International Meteorological Congress at Paris in 1899. Mascart summarized the result of the discussion as follows: "One has often alleged the southward retrogression of the limit of culture of the vine. But this fact does not prove anything. At a time when transportation was difficult one contented himself with vines that gave one or two good vintages in 10 years, vintages that one preserved very carefully. The other years gave but a poor drink with which one got along for lack of better and which on the other hand perhaps equaled our artificial wines." [5]

One often cites historic documents to the effect that during some centuries the vine was cultivated even in England and that wine was made there. The first to speak of this is Bede. He says: "Vineas etiam in quibusdam locis germinas" (Hist. Ecclesiast. t.). In the Domesday Book several places are mentioned where the vine was cultivated, thus at Rayleigh in Essex, where in good years the vintage yielded 20 "modii" of wine from a surface of 6 "arpennes." In certain old English books we often find mention of places where the vine was cultivated. Thus, in the time of King Edward II, wine was on sale from a vine at Ely, but in the time of Edward IV this culture had stopped. Even in 1685 Dr. Bathurst, president of Trinity College, Oxford, made from his grapes "as good claret as one would wish to drink." But one is always dealing with *isolated localities*, and Lord Bacon expressly says that "the grapes require a south wall to ripen." But under this condition one can cultivate them even to-day in southern Sweden. I myself have seen the grapes mature at Kalmar when against walls facing south.

It has also been claimed that the mean epoch of the vintage has been retarded. In his great "Étude sur les vendanges en France" Angot[6] has shown that, on the average for almost the whole of France, there is a mean difference of about 11 days between the dates of vintage in two consecutive years, and that the observed difference between the *extreme dates* during a long series of years generally exceeds 60 days. This variation often occurs between years close together. Thus the difference between the dates of vintage of 1816—one of the most tardy years—and of 1822—one of the earliest years—exceeded 40 days throughout almost the whole of France, and amounted to 60 days at Loches, 62 at Chize, and 70 at Vesoul. However, there does not exist any retardation in the epoch of the vintages. It is true that at Dijon, for example, from 1750 to 1850 the grapes were harvested much later—on the average about seven days—than from 1625 to 1725. At Salins the variations are much less distinct and even rather in the opposite sign, for the period 1700–1800 shows an advance of four days over the period 1550–1650. The greatest difference between two periods of a hundred years is found at Aubonne, the vintages between 1575 and 1675 were there made earlier on the average than those between 1675 and 1775.

"This fact," says M. Angot, "have led some authors to infer that there has been a modification, a cooling off of our climate. But one may remark first of all here that these variations do not seem to take on the appearance of a change that would always proceed in the same direction, such a change as would result from a progressive deterioration in the climate; rather they seem to be oscillations. Thus from 1775 to 1875 the mean epoch of the vintage at Aubonne advances by 10 days over that for the preceding secular period, and it is only 3 days behind the epoch that had been recorded two centuries previous. To-day the vintage date at Aubonne has returned exactly to the date for the sixteenth century. The curve for Dijon, Plate II [not reproduced], also shows a marked tendency to descend, a return to the earliest dates of vintage. Therefore it can not be a question of a permanent deterioration in climate. One may even go further and advance the idea that these slow oscillations in the mean epoch of the vintage are not due to even periodic changes in the climate. In fact, the three stations of Dijon, Salins, and Aubonne are sufficiently near together so that long-period variations in climate should run parallel; in any case the variations at Salins ought to be intermediate to those at the two other stations. Now a simple inspection of the three curves is sufficient to assure oneself that not the slighest parallelism exists. Analogous differences occur between stations much closer together; thus at the beginning of the seventeenth century the mean date of vintage at Lavaux was 10 or 12 days earlier than that at Aubonne, which is also located on the border of the Lake of Geneva and only 25 kilometers distant; at present the mean difference between the vintage date of these two stations is but 1 day.

Again, it is certain that in Burgundy the culture of the vine has not varied since antiquity; the nature of the vine stock, the mode of culture, the localities where the grape develops the best qualities have all remained the same as those described by Columelle in his book "De re rustica," and later by the precise documents on the culture of the vine since 1330 at Beaune, and 1430 at Dijon. We also know that since the time of Gregory of Tours—that is to say, since the sixth century, the great wines of Burgundy have been produced on the same hills and the same parts of the hills—that is to say, the intermediate zone. The same vine stocks carried somewhere else, to another climate or even to a slightly different altitude, give products of no longer recognizable character. One must then conclude from this that for at least 10 centuries the climate of France, and of Burgundy in particular, has not changed in any appreciable fashion. The long-period variations in the epochs of the vintages, variations which are dissimilar in very near-by regions, therefore depend not on changes in the climate but on purely local causes, such as slight modifications in the nature of the vine stock or in the mode of culture, a replanting of the vines, increase in the number of stocks, etc.

OPENING OF LAKES AND RIVERS.

From Sweden we have uninterrupted observations of the breaking up of the ice since 1712 at the port of the town of Westerås on the north shore of Lake Mälaren. In Russia

[4] Further details in: *Hildebrandsson, H. H.*, Quelques recherches sur les centres d'action de l'atmosphère: V. K. Sv. vetensk. Ak. hdlgr., 1914, 51, No. 8.
[5] Procès verbaux, Congrés météorologique international, Paris, 1889. p. 15.
[6] *France.* Bureau central météorologique. Annales, 1883, I.

Rykatchev [7] has published a memoir on the opening of the Russian rivers. The longest series of these is that for the Neva at St. Petersburg (Gregorian calendar) and for the Dvina (Düna) at Mitau (Julian calendar).[8] The former extends without interruption from 1713 and the latter from 1530, but unfortunately gaps occur particularly at the beginning of the sixteenth and at the end of the seventeenth century. The series is complete from 1709.

Observations are recorded in Tables 1 to 3. These tables show that the time of the opening has varied considerably from one year to the next, and even the 10-year means differ considerably. Thus Lake Mälaren has been free from ice by May 8, on the average, during the time 1803–1812 and by April 14 during 1723–1732; the Neva has been open by April 27 during 1803–1812 and 1843–1852, and by April 26 during 1733–1742, but the average has been April 17 during the decade 1853–1862, while the Dvina (Düna) opened on April 4, 1804–1812, and on March 16 on the average of the 10 observations that we have between 1651 and 1712.

But on taking the means for Lake Mälaren for the years 1753–1822 = 70 years, one finds April 26, while for the years 1823–1892 = 70 years, one finds April 25. Similarly we find for the Neva from 1713–1792 = 80 years, April 9; from 1793–1862 = 70 years, April 8; and 1793–1871 = 79 years, April 10.

For the Dvina (Düna) we have the following table:

1530–1752=106 years	averaged	March 25
1753–1852=100 years	do	March 26
1530–1623=52 years	do	March 28
1626–1750=52 years	do	March 24
1751–1802=52 years	do	March 25
1803–1852=50 years	do	March 28
1530–1852=206 years	**do**	**March 26**

TABLE 1.—*Breaking up of ice on Mälaren at Westerås, 1712–1892.*

[Abstracted from detailed table.]

Years.	Interval.	Means.		Years.	Interval.	Means.	
		Date.	Day of year.			Date.	Day of year.
	Years.				*Years.*		
1712–1722	11	Apr. 20	111	1823–1832	10	Apr. 25	116
1723–1732	10	Apr. 14	105	1833–1842	10	Apr. 25	116
1733–1742	10	Apr. 19	110	1843–1852	10	Apr. 28	119
1743–1752	10	Apr. 26	117	1853–1862	10	Apr. 23	114
1753–1762	10	Apr. 21	112	1863–1872	10	Apr. 24	115
1763–1772	10	Apr. 27	118	1873–1882	10	Apr. 30	121
1773–1782	10	Apr. 22	113	1883–1892	10	Apr. 23	114
1783–1792	10	Apr. 20	120	Extremes:			
1793–1802	10	Apr. 24	115	1822		Mar. 15	75
1803–1812	10	May 8	129	1881		May 20	141
1813–1822	10	Apr. 25	116				

TABLE 2.—*Breaking up of ice in the Neva, 1713–1872.*

[Abstracted from detailed table.]

Years.	Interval.	Means.		Years.	Interval.	Means.	
		Date.	Day of year.			Date.	Day of year.
	Years.				*Years.*		
1713–1722	10	Apr. 25	116	1813–1822	10	Apr. 18	109
1723–1732	10	Apr. 19	110	1823–1832	10	Apr. 17	108
1733–1742	10	Apr. 26	117	1833–1842	10	Apr. 22	113
1743–1752	10	Apr. 20	112	1843–1852	10	Apr. 27	118
1753–1762	10	Apr. 18	109	1853–1862	10	Apr. 24	115
1763–1772	10	Apr. 20	111	1863–1871	9	Apr. 26	117
1773–1782	10	Apr. 22	113	Extremes:			
1783–1792	10	Apr. 25	116	1822		Mar. 18	78
1793–1802	10	Apr. 18	109	1810		May 12	133
1803–1812	10	Apr. 27	118				

[7] Wild's Repertorium für Meteorologie, St. Peterburg, 1887. Supplem. Band II.
[8] Kupfer. Correspondance météorologique, 1852. St. Petersbourg, 1853, p. XXXII.

Thus, in spite of the great variations even in the 10-year means, *the average arrival of springtime has been constant in the Baltic region at least since the beginning of the sixteenth century.* There is little probability that a much more severe climate prevailed during the fourteenth and fifteenth centuries, and in any case we should not have to do with a regular variation.

The objection might be offered: Although the arrival of spring has not varied yet the climate may have become more marine or more continental during the later centuries. Perhaps the winters of the fifteenth century were more severe than at present, although the dates of the opening of rivers have remained the same.

It is easy to refute this objection. As a matter of fact the date of the opening of a stream depends primarily upon the degree of cold of the past winter.

In Table 4 we have entered first the mean temperature at Thorshavn on the Faroe Islands and at Berufjord on the northeast coast of Iceland for the coldest months January–February; second, the means for January–February at Upsala, about 70 kilometers distant from Westerås; third, the day of the year on which the ice went out of the harbor at Westerås. *It is apparent that the departures of the mean temperature at Upsala and of the mean dates at Westerås almost always have opposite signs;* this is particularly the case if the departures are considerable. *A rigorous winter temperature brings a retarded date of opening of the harbor and a mild winter is followed by an early opening.*

Now if the dates of the opening of the river have been constant since the Middle Ages the climate has not grown either more continental or more marine, at least to a sensible degree (see also Plate III, not reproduced).

In my researches on the centers of action of the atmosphere I have proved that the winter temperatures in the Baltic region is determined by the temperature of the ocean between Iceland and Norway. We see from Plate III that with barely three exceptions the departures at Berufjord and at Thorshavn have the same sign as those at Upsala.[9]

But then one must conclude that *if the climate of the Baltic region has not changed the climate of the district about Iceland has also remained constant.*

TABLE 3.—*Breaking up of the ice in the Dvina (Düna), 1557–1852.*

[Abstract from detailed table.]

Years.	Interval.	Means.		Years.	Interval.	Means.	
		Date.	Day of year.			Date.	Day of year.
1557–1571 [1]	10	Mar. 26	86	1773–1782	10	Mar. 24	84
1572–1584 [2]	10	Mar. 21	81	1783–1792	10	Mar. 29	89
1585–1594	10	Mar. 28	88	1793–1802	10	Mar. 21	81
1595–1616 [3]	10	Mar. 25	85	1803–1812	10	Apr. 4	95
1617–1650 [4]	10	Mar. 23	83	1813–1822	10	Mar. 23	83
1651–1712 [5]	10	Mar. 16	76	1823–1832	10	Mar. 25	85
1713–1722	10	Mar. 27	87	1833–1842	10	Mar. 24	84
1723–1732	10	Mar. 27	87	1843–1852	10	Mar. 29	89
1733–1742	10	Mar. 20	80	Extremes:			
1743–1752	10	Mar. 25	85	1652		Jan. 23	23
1753–1762	10	Mar. 23	83	1659		Apr. 22	113
1763–1772	10	Mar. 29	89				

[1] 1559–1561, inclusive, missing.
[2] 1573–1575, inclusive, missing.
[3] 1599–1600, 1603, 1608, 1610, 1611, 1613, 1614, missing.
[4] 1620, 1624, 1625, 1627–1642, 1644–1648, inclusive, missing.
[5] 1654–1658, 1660, 1661, 1663–1666, 1668–1708, inclusive, missing.

[9] For details see: *Hildebrandsson*, Quelques recherches sur les centres d'action de l'atmosphère.

TABLE 4.—*Mean temperature of January and February at Thorshavn and Berufjord and at Upsala, compared with the breaking up of the ice on Mälaren at Westerås.*

Year.	Thorshavn and Berufjord means.	Departure.	Upsala mean.	Departure.	Mälaren opened.	Departure.
	°C.	°C.	°C.	°C.	Day.	Day.
1875	+1.6	+0.7	−9.0	−4.3	129	+ 1
1876	+1.8	+0.9	−4.7	0.0	118	− 1
1877	−0.2	−1.1	−6.8	−2.1	135	+16
1878	+1.5	+0.6	−2.8	+1.9	107	−12
1879	+0.5	−0.4	−6.8	−2.1	123	+ 4
1880	+2.8	+1.9	−2.3	+2.4	112	− 7
1881	−2.8	−3.7	−9.2	−4.5	141	+22
1882	+1.5	+0.6	−0.7	+4.0	139	+20
1883	+3.0	+2.1	−3.7	+1.0	122	+ 3
1884	+1.5	+0.6	−2.6	+2.1	100	−19
1885	+1.0	+0.1	−3.9	+0.8	114	− 5
1886	−0.6	−1.5	−3.8	+0.9	110	− 9
1887	+2.0	+1.1	−0.3	+4.4	97	−22
1888	−0.6	−1.5	−4.7	0.0	134	+15
1889	0.0	−0.9	−3.5	+1.2	122	+ 3
1890	+2.9	+2.0	−1.7	+3.0	97	−22
1891	+2.5	+1.6	−2.2	+2.5	122	+ 3
1892	−1.2	−2.1	−5.7	−1.0	118	− 1
Means	+0.9	.....	−4.7	.....	119	.....

SUPPOSED CHANGE IN THE CLIMATE OF ICELAND.

It has often been claimed that the climate of Iceland has grown more severe since its colonization, because the forests that once covered the island "from the mountains to the shore" (Fra fjeld til strand) have almost disappeared, while agriculture and cattle raising have greatly fallen off.

However, the Icelander, Th. Thoroddsen, professor at Copenhagen and the greatest authority on his native isle, has recently proved that these changes have resulted from *economic and political causes*—i. e., they are due to man and not to a *change in the climate*.

As for the forests, some of them still remain in the unsettled portions of northern Iceland, but one must observe that in Iceland one still calls the brush of dwarfed birch (*Betula alba*) with scattered examples of *Sorbus aucuparia*, *Salix phylicifolia*, and *Salix glauca* by the name of forests (Skogar) as in other days, not meaning the tall forests as in Europe. One occasionally finds a birch 6 to 9 meters high in a well-sheltered valley. The "forests" of other days did not have taller trees. In the peat bogs occur fossil trees whose dimensions are as small as those of to-day and the oldest Icelandic annal (Saga, pl. Sagor) mentions persons going to Norway to buy wood from which to build their houses. At the beginning of the eleventh century St. Olaf, king of Norway, granted the Icelanders the right to take wood from the State forests.

If Iceland became depopulated, undoubtedly the shrubbery would re-wood the island, but at present the immense flocks of sheep living in the open air throughout the year devour the buds of the plants as they are beginning to put out. The decrease in forests has therefore nothing to do with the climate.

It has been the same with *the ancient Icelandic agriculture*. The first colonists, accustomed to cultivate the soil, started in immediately with this labor in their new country also; but agriculture met with poor success. Barley (*Hordeum vulgare*) was the only grain sown, as was the custom at that time in northern Norway and still prevails to-day in Swedish Lapland; but generally barley only ripened in very good years. In general, one could not make bread of it, only gruel and beer; but as they had no hops it was necessary to prepare the beer immediately before using it; and it seems to have often happened, as the ancient records relate, that "the beer was bad and the diners remained sober."

In fact, bread was regarded as a *rare luxury*, and the little that one had of it was generally imported. In 1174 the archbishop at Nidaros (Drontheim) received the right to export to Iceland "triginta leste farina." Farina is translated by *miol;* that is to say, the meal of barley in the Icelandic text.[10] The price of "miol" in Iceland was very high in the year 1200. One could buy a good cow or a horse for 104 k. of miol. To take the place of bread the Icelanders ate dried fish (*skreid*). The accounts of the bishop at Holar for the year 1374 show that in that year there had been consumed 8,800 pd. of "skreid," 7,200 pd. butter, and only 60 pd. of flour. Wheat (*Triticum vulgare*) and white bread were extremely rare articles at that time there and when in 1237 the pope forbade the use of barley and beer in celebrating the Holy Sacrament, the bishops of Skalholt obtained a monopoly of importing wheat and wine for the churches.

It is true that barley had been cultivated in Iceland for three or four hundred years, but step by step and to the extent that the imported grain became cheaper—particularly after the beginning of English commerce about the middle of the fifteenth century—its cultivation has diminished and finally has almost ceased. *But the cause of this diminution is purely economic and has nothing at all to do with the climate.*[11]

The great herds of cattle and of sheep are raised on the broad verdant plains. We have seen that much butter was consumed. In fact, every peasant lived from the products of his land and the only things that he had to buy abroad were the wood, iron, and salt, for which he paid in woolen cloth, which was legal tender. But as commerce developed one could secure bread, beer, and many other products, which contributed to make the bill of fare of the peasant more agreeable and his whole life more comfortable. But the cattle, under the very primitive and poor methods of raising, gave products not suited to export, while the wool is greatly sought after abroad, even to-day, and together with fish constitutes the most important article of export. For this reason came the steady decrease in cattle raising, the increasing flocks of sheep in Iceland, and *not at all because of a change in climate.*

As is well known, Iceland's climate is marine. The summers there are cold, about +10°C., andthe winters are not rigorous. But from time to time it comes to pass that masses of floating polar ice extend down to the northern coast of Iceland and, driven by the current from west to east, drift down to its east coast. Under those circumstances the whole northeastern portion is blockaded by the ice and on rare occasions the polar ice even extends to the south coast. Such a blockade by the ice always brings in its train a very cold season. The sheep, which as we have just seen always live in the open, then die in great numbers and if the ice remains until spring or even into the summer a famine results. According to the ancient records, it has several times happened that men have died of starvation by the hundred, and it has even come to pass that the aged or the invalid were put to death in order to escape the necessity of feeding them. Every Icelander knows that a year of dearth is caused by a more or less severe blockade of the coast.

It appears that the average position of the polar ice has not changed in the vicinity of Iceland since the date of the first description of that country, for which we are indebted to the monk Decuilus, who lived about the year 825. He says that *the sea about Iceland is generally open,*

[10] Wheat flour is *hveiti* or *flur* in Icelandic.
[11] It is thus with Icelandic agriculture as it is with the grape culture of northern France.

"but on sailing for a day toward the north one meets the frozen sea." This is in perfect accord with what one experiences to-day during those years when there is no ice blockade. One generally meets the edge of the ice at a distance of one day's travel (in the boats of those times) north of Cape Langanes.

Pettersson says that in earlier times it would seem that the ice blockades of Iceland were less severe than they are to-day, since the phenomenon is rarely described in the oldest annals, although very frequently after the end of the thirteenth century. Thoroddsen replies that this is for the simple reason that the annual records begin only at the end of the thirteenth century. The ancient records, the "sagor," describe the life and customs of the distinguished families. Nevertheless, one often meets therein with accounts of years of dearth, horrible famines, rigorous winters, etc.; in other words, the *ordinary results of the ice blockades*. Also they frequently speak of the white polar bears which visited Iceland only across the ice. Their numbers must have been rather large, because the church inventories often mentioned the skins of the white bears on which the priests kneel before the altar in winter.

One of the first colonists, Flokivilgerdarson, looking from the summit of a mountain in the spring of 865 A. D., saw the fjords on the northwest filled with ice, and for this reason he named the new country *Islande*, i. e., the land of ice. But in that year the ice blockade must have been very widespread for it is only in such a case that the northwestern fjords are filled with ice.

Thoroddsen has found in the old annals the description of eight years of famine during the tenth century and of six during the eleventh. But here it is a case of extraordinary famines only, when "men die by the hundreds," "when they ate foxes and crows," "when they killed the old and the weak," etc. The end of the twelfth century and the beginning of the thirteenth was a period during which famines were of terrible frequency. According to Pettersson, of the 58 years, 1291–1348, at least 29 must have been years of dearth, but Thoroddsen remarks that this is an error. According to the registers there were 43 years of average yield, 12 years of dearth, and 3 very good years. During this period there also occurred volcanic eruptions a number of times and also earthquakes, but these phenomena have nothing to do with the climate. According to him, without doubt the fourteenth century brought severe periods, but it was exceeded in this respect by the seventeenth century.

Thus, as we have seen when studying the breaking up of the rivers, we here find again severe periods alternating with warm ones,[12] *but one can not demonstrate a change in climate.*

SEVERE WINTERS AND FREEZING OF THE SEAS.

There are numerous accounts of severe winters and of freezing of the seas from antiquity down to the present.[13] Capt. C. I. H. Speerschneider, of the Royal Danish Meteorological Institute, has long been studying all accounts of these phenomena in Danish waters which he has been able to find, and has recently published the results of his researches in a very interesting memoir. * * *[14]

After having spent several years studying and critically discussing the details of the recorded conditions of the winter ice in the waters about Denmark, Capt. Speerschneider has drawn up the following table (Table 5) of severe winters during which some portions of these waters have been filled with ice.

TABLE 5.—*Severe winters in Danish waters.*

XI.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.
					1601			1901
			1402				1802	
							1803	
							1804	
							1805	
		1306						
				1507				1907
			1408		1608			
						1709	1809	1909
					1610			
							1811	
								1912
							1813	
							1814	
					1615	1715		
						1716		
					1619			
		1320			1620		1820	
			1421		1621		1821	
					1622			
		1323	1423				1823	
				1524				
			1426			1726		
							1827	
			1429		1629		1829	
							1830	
			1431				1831	
					1632			
		1333?						
				1536				
					1637			
							1838	
		1340				1740		
							1841	
							1844	
							1845	
		1346		1546				
1048				1548?			1848	
		1349						
						1751		
					1652			
							1853	
					1655	1755		
		1357						
		1358	1458		1658	1758	1858	
					1659			
	126?		1460			1760	1860	
	(?)						1861	
	(?)							
	(?)				1663	1763		
	(?)							
					1665	1765	1865	
					1667	1767	1867	
						1768	1868	
				1569				
					1670	1770	1870	
				1571		1771	1871	
				1572		1772		
				1573				
					1674	1774		
							1875	
						1776		
					1677	1777		
							1879	
							1880	
							1881	
				1583				
					1684	1784		
						1785		
	1286			1586		1786	1886	
				1587				
						1788	1888	
				1589		1789	1889	
				1590				
				1591			1891	
				1592		1792		
				1593			1893	
		1394						
				1595	1695	1795	1895	
	1296							
					1697		1897	
					1698			
		1399		1599		1799		
						1800	1900	

[13] Often there is a whole series of years when the Icelandic coasts are relieved of the ice blockade, e. g., 1841–1854 and 1903–1910 in our times.

[13] One of the largest of these compilations is that by Baron Ehrenheim in his farewell address before the Academy of Sciences at Stockholm in 1824, viz, Om Climaternas rörlighet (The variations of climates).

[14] *Speerschneider, C. I. H.* Om isforholdene i Danske farvande i eldre of nyere tid. Aarene 690—1860. (Danish Meteorol. Instit., Publication, Mitt. 2.)

[This paper was abstracted in this REVIEW, May, 1915, 43: 236, and its contents need not be here repeated.—C. A., jr.]

The series is complete since 1750 down, and during this period we have had severe winters as follows [in Denmark]: 1750–1799, 22 times; 1800–1849, 21 times; 1850–1899, 21 times.

Table 6 shows how many years have been marked by floating ice and how many years have permitted traffic on the ice in the different portions in the Danish waters.

TABLE 6.—*Number of years with floating ice (column I) and with traffic upon the ice (column II) in Danish waters.*

Century.	Cattegat.		Le Sund.		Gr. belt.		L. belt.		Femern belt.		Baltic.[1]	
	I	II	I	II	I	II	I	II	I	II	I	II
Fourteenth	1	....	2	....	2	.....	1	.....	6	5	.....	(2)
Fifteenth	3	....	3	2	2	.....	.....	.....	6	4	3	1
Sixteenth	.....	.....	12	3	4	3	2	.....	3	3	1	.....
Seventeenth	3	....	16	9	10	3	6	3	5	2	3	1
Eighteenth	9	....	33	13	23	3	11	6	6	1	3	1
1800–1850	7	....	19	9	28	1	9	3	6	.....	5	1

[1] This refers to the northern part of the Baltic between Denmark and Germany.
[2] According to Olaus Magnus, one traveled across the ice of the Baltic between Germany and Denmark in 1323 and 1399, years also cited in Speerschneider's table of severe winters, pp. 63 and 65.

Since 1750, when we have continuous observations, the number of severe winters in a 50-year period have remained constant at 20 to 22. Previous to that time observations grow fewer and fewer for each century preceding. Now it is impossible to prove whether the number of severe winters has increased, decreased, or remained constant since the fourteenth century. However, traffic on the ice in the Baltic is so rare an event that it probably would have been recorded. According to this, it would seem that this event occurred once in a century.[15] Speerschneider has also found observations on the appearance and disappearance of ice in the Danish waters. He has found as follows:

Dates.	Number of years.	Began.	Ended.	Days.
1296–1750.	21	Jan. 20....	Mar. 23....	56
1763–1860.	98	Jan. 25....	Mar. 19....	54

It is therefore probable that the frequency, the duration, and consequently also the amount of ice has been constant since the thirteenth century.

The frequently exaggerated accounts of formidably severe winters during the Middle Ages have caused nearly all students in the northern countries, from the time of von Ehrenheim down to Pettersson and Ekholm, to admit that the winters have been much more rigorous in the past with a maximum cold in the fourteenth century. Pettersson seeks to explain the more frequent freezing of the Baltic in those times by hydrographic phenomena. Hydrographic researches—excellently organized in large part by himself—have shown that the salt water of the Kattegat intermittently invades the Baltic through the Sund and the Belts, where it rolls along the bottom and fills the deepest parts. Upon this layer of specifically heavy water rests the upper less salty water of the Baltic. One may often catch fish from the Kattegat even in the shallow strait between Kalmar and the island of Öland. It is sufficient to admit that the straits between the Kattegat and Baltic have been only a few meters deeper [16] in order to bring about a more marked exchange of water between the two seas. Now the level of the salt water in the Baltic would have to rise and the depth of the upper layer would have to decrease. It is evident that under such circumstances the Baltic would freeze over more readily than at present.

In support of this hypothesis Pettersson cites the Hanseatic herring fisheries in the Sund and southern Baltic. But it seems not improbable that in a time when transportation was difficult one was satisfied with a yield less good, as was the case with the vintages of northern France and the barley of Iceland. In fact, the true herring *Clupea harengus* (Swed. *sill*) to-day is taken only in the southernmost part of the Kattegat [17]; but there is a variety in the Baltic, *Clupea harengus var. membras* (Swed. *strömming*). This variety is smaller than the true herring and becomes yet smaller progressively as the water northward grows less salty. There are still great fisheries of *strömming* throughout the Baltic even into the Gulf of Bothnia. On the southern coast of Sweden this fish grows larger and they call it the *sill*. The *sill* of Blekinge is even famous as an excellent one. Was it perhaps the Baltic herring which the Hansas caught?

Finally, Norlind has recently remarked [18] that these fisheries began 200 years before and finished shortly after the beginning of maximum cold mentioned by Pettersson.

Pettersson has also pointed out that during the 13th and 14th centuries there were frequent storms and invasions by the sea along the east and south coasts of the North Sea where the dykes were destroyed and large portions of the cultivated land devastated. Norlind remarks that the construction of dykes was initiated at the beginning of the 13th century. It is therefore natural that at that time one did not understand how to construct sufficiently strong dykes; gradually the inhabitants have learned how to give them the necessary power of resistance, and so these catastrophes have become more rare. "So it is not at all necessary to hunt for the causes of these catastrophes in climatology, but rather in anthropogeography."

Speerschneider and Norlind both reached the same result, viz, *there was no period of climatological catastrophes* (Klimatologisches Katastrophenzeiten) *in the 14th and 15th centuries and the climate of the Middle Ages was sensibly the same as that of to-day.*

METEOROLOGICAL JOURNAL OF TYCHO BRAHE, 1582–1597.

In 1876 the meteorological committee of the Royal Academy of Sciences at Copenhagen published the meteorological journal maintained by Tycho Brahe from 1582–1597 at his famous observatory Uranienborg on the island Hven in the Sund.[19] These observations embrace all the meteorological observations that one can make without instruments, the latter not having been invented in those times, viz, the amount of snow, days with rain, with snow, with fog, with grésil or with hail, direction and velocity of the wind, hoarfrost [gelée blanche], thunderstorms, auroras, solar halos, remarks on the ice in the Sund, etc. The Danish edition closes with a résumé by Paul la Cour, wherein he compares the annual variations of the various meteorological elements com-

[15] It would have been possible in 1893 to cross the Baltic on the ice, had not modern steamers kept wide channels open.
[16] He has studied the Danish marine charts, but the oldest of the seventeenth century still show the same depths in the Sund as are found to-day.
[17] Sometimes the true herring descends into the Sund, as in September, 1915, when they were caught there, but this is of rare occurrence.
[18] *Norlind, Arnold.* Till frågan om det historiska klimatet, särskilt i Nord- och Mellaneuropa. Ymer, 1915, p. 94.
Norlind, Arnold. Einige Bemerkungen über das Klima der historischen Zeit nebst einem Verzeichnis mittelaltlicher Witterungserscheinungen. Lunds universitets årskrift. N. F. Afd. 1, Bd. 10, no. 1.
[19] Tyge Brahes meteorologiske Dagbok, holdt paa Uranienborg for Aarene 1582–1597 Kjöbenhavn, 1876. (Acad. roy. d. sci., Commit. météorol. App. aux Collectanea Meteorologica.)

puted from Tycho's observations, with those found at Copenhagen and other Danish stations during the past century. Ekholm made, in 1899, a similar comparison between the observations by Tycho and those for 1881–1898 at the Swedish meteorological station erected on the spot occupied by Uranienborg.[20] The latter have shown that there the climate of the spring and the autumn has remained constant since the time of Tycho. Ekholm has found, in fact, the following result:

Dates of first and last frosts at Uranienborg then and now.

Years.	Last frost in spring.	First frost in autumn.
1582-1597	April 18	October 27
1881-1898	April 19	October 28

This confirms the result reached by us above in discussing the breaking up of the river ice.

Paul la Cour, however, found a difference in the winds of 1582–1597 and those of our times. The prevailing wind, to-day from the southwest almost throughout the year, was generally from the southeast in those days, specially in winter. Ekholm remarks with reason, that the winters must have been colder then than they are to-day. In fact a southeast wind in winter on the Sund signifies a high pressure over northern Sweden and a low pressure over northern Germany. Now, barometric depressions in those times passed farther south than they do to-day, particularly in the winter time. Such a pressure distribution always occurs during cold winters. It has been supposed that this wind régime, which is so different from that of our day, was simply due to bad exposures of the vane. Such a supposition is altogether improbable in the case of observations made in the most illustrious observatory of the time. It is easy to convince oneself that the observations are accurate. From the observations published in the journal from January to March we have calculated the number of winds from each compass point for the very cold winter of 1595 and the very mild winter of 1588. The winter of 1593 was very mild up to February 15, but very rigorous in March. We have separately computed the wind from January 1 to February 15 and from March 1 to 31 in that year. The results are given in Table 7.

TABLE 7.—*Frequencies of winds from respective directions at Uranienborg.*

Year.	SE.	E.	NE.	N.	NW.	W.	SW.	S.
1595	25	11	30	16	22	12	21	10
1588	8	8	8	10	18	26	14	5
Jan. 1–Feb. 15, 1593	5	2	3	0	5	9	13	4
March, 1593	7	15	6	0	1	0	0	0

Thus one sees that the easterly winds predominated during the severe winters and the westerly winds in the mild winters, just exactly as to-day. It is therefore well established that the winters 1582–1595 were in general more severe that the winters of to-day.

But this does not justify one in concluding that the winters of the sixteenth century were colder in general than those of the past century. In fact one sees from Table 5 that the sixteenth century had 19 severe winters, when the Danish waters were filled with ice; but of these 19 cold winters 9 occurred between 1582 and 1597. This proves that that period was a cold one as was the period from 1802–1812, which caused the late breaking up of the rivers as we have seen above.

So the observations of Tycho Brahe do not permit us to establish any change in climate.

[20] Ymer, 1899.

GLACIERS.

The Alpine glaciers are known to be subject to periodic variations. During a series of years they advance in the valleys. The glacier pushes before it its frontal moraine and at times prolonging itself beyond measure invades pastures, overturns forests and buildings. Finally it halts and after a rest it retreats toward the high valleys during a new series of years. We also know that the advance and retreat of a glacier does not depend upon the amount of snow that falls during the winter nor the high temperature of the summer during the preceding year. The mass of snow added to the glacier during a single winter and the heat of a single summer which causes its melting and ablation, do not suffice to produce a noticeable effect. "The determining factor in the variations in length of the glacier," says M. Forel,[21] "is not ablation but the speed of movement of the ice." The relative length of a glacier depends on the relative value of these two simultaneous processes, the motion of the river of ice and the melting of the ice. Of these two factors the melting is subject to annual and irregular variations. This essentially irregular factor would not be the one which occasioned variations of such long periodicity and also of such uninterrupted periodicity as those that we observe in glaciers. But it has been found that the speed of motion varies with the thickness of the glacier; and this is determined by the depth of the névé just as the water of the river increases or diminishes according to the discharge at its source. The névé is formed by the sum of the layers of snow fallen during the preceding years and accumulating one upon the other. In accumulations of this nature there are variations of long period, for, as we have pointed out above, there are series of years when the temperature, or the amount of rainfall or snowfall, is greater or less than the normal. So that it suffices, as a cause of the variation in the length of the glacier, to hunt for variations in the depth of the upper part of the glacier, variations continuing in the same direction throughout long periods of many years. Heim [22] has very properly called a glacier a *climatometer*.

All the Swiss glaciers show movements generally of the same sign.[23] However, the smallest glaciers and those having an abrupt slope begin to advance, and to retreat, somewhat earlier than the large ones. Consequently it happens in certain years that the movements of two glaciers are of opposite sign. But we may not go into more detail here regarding the glaciers. The only question that interests us at present is: Has there been a change in the extent of the glaciers in historic times? All students that have considered this question agree that *in the Middle Ages the extent of the Alpine glaciers was less than it is to-day, but that toward the middle of the sixteenth century they began to advance in a disquieting manner*. This is well proved. For example, Polybius mentions gold and silver mines

[21] *Forel, F. A.* Essai sur les variations périodiques de glaciers. Arch. d. sci. phys. et nat., Genève. 1881.
[22] *Heim, A.* Handbuch der Gletscherkunde, p. 500.
[23] According to Heim one does find such a parallelism between the movements of all the glaciers of Europe and Asia.

in the Hohen Tauern that were still exploited in the Middle Ages. But at the middle of the sixteenth century all the workings were covered by a glacier. In 1570 the sheet of ice had a depth of 25 meters, which increased to 100 meters during the eighteenth century and then decreased. About 1880 the depth was only 40 meters and later during periods of retreat it has come to pass that the débris of wrecked buildings have reappeared after having been interred in the ice almost 400 years.

According to the record of the church at Grindelwald there was an almost uninterrupted series from 1539 to 1563, of winters with very little snow and often very warm summers. From 1565 to 1580, on the other hand, there was a period of very snowy winters. Thus in the middle of the century or about 1540 there commenced a period of extreme regression, during which the lower glacier of the Grindelwald did not pass the upper rocks (die obern Flühe), while from 1565 on the névés have been increasing. In 1580 the glacier began to pass beyond the rocks and to descend into the gorge; in 1584 the chapel of Sainte-Pétronelle was overturned,[24] and in 1588 a barn was destroyed; in 1593 the glacier reached to the village, invaded two chalets and a large number of barns, and shifted the bed of the Black Lütschine and of the Bergelbach. A road between Oberwallis and Grindelwald was buried beneath the ice. During the great retreat of the glaciers from 1860–1880 portions of this road were seen to reappear.[25]

According to Heim *it is not possible to say whether we are approaching a new glacial period or whether we have to do with a long secular variation in the glacier movements.*

THE REMAINS OF ANCIENT FORESTS IN SWEDEN.

Some botanists have maintained that Sweden's climate has grown colder because to-day forests occur only on the Scandinavian Alps while one finds the evident remains of forests that have been destroyed. In fact the researches in Swedish Lapland along the eastern slopes of the Scandinavian Alps, and particularly those by Gavelin,[26] have proved that rather recent remains of dead trees are to be found almost everywhere above the upper limit of the conifers. *It is particularly the pines (Pinus sylvestris) that have perished;* the remains of the spruce (*Pinus abies*) or of the birches are rather rare.

But observations have also shown that forests often spring up again. The truth probably is that the forests along their limit of vegetation, increase during a certain number of years, following which another series of years with excessive cold kills them off. Then after a new series of years with mild winters they again begin to grow up.

But higher up in the region of birches and even above it we find in the swamps and bogs quantities of subfossil pine probably dating from the "Atlantic and subboreal period" of Sernander during which the temperature was so high that hazel nuts matured in Lapland. From this time also probably date the oaks buried in the sandy shores of the Clara River in Vermland which one often finds there buried at a depth of 2 to 4 meters beneath the surface of the soil in localities much farther north than the present limit of the oak.

We will not here go into further details concerning these interesting questions to which a final answer has not yet been found.

[24] According to an unverified tradition the bell dated from 1044 A. D.
[25] For further details see *Heim*, op. cit., p. 512–516.
[26] *Gavelin, Axel.* Trädgränsförskjutningarna inom Kamajokks vattenområde (Lilla Lule älf.). Sveriges Geologiska Undersökning, Årsbok, 1909, **3**, no. 10.

CONCLUSION.

Our researches have led to the result that there exist everywhere climatic variations of long and short duration, but it is not possible to prove that the climate of Europe has changed for either better or worse during historic times.

P. S.—"As I am closing these researches [last signature was printed Dec. 14, 1915] I am in receipt of the interesting memoir by Prof. J. W. Gregory "Is the Earth Drying Up?"[27] which contains a criticism of the theories put forward by Prince Kropatkin and Prof. Ellsworth Huntington that our earth is steadily growing drier and drier. Gregory's researches have led him to the same result I have reached. "One fact," he says, "does seem to me to result clearly from the evidence; there have been many widespread climatic changes in late geologic times, while in historic times there has been no world-wide change of climate."

VIOLENT EASTERLY WINDS AT TATOOSH ISLAND, WASH.

By RALPH C. MIZE, Observer.

[Dated: Weather Bureau, Tatoosh Island, Wash., Mar. 18, 1916.]

Wires and shrubbery on Tatoosh Island received a heavy coating of ice during the prevalence of a strong easterly breeze on the early morning of February 1, between easterly storms. The rigging of the radio station was covered with from ¼ to ¾ inch, varying with elevation from ground level to 250 feet above, and the aërial was torn away by the excessive weight of the ice. Thawing extended, during the day, to a height of approximately 75 feet, but the coating on the upper 175 feet was not appreciably diminished until it was cracked by the swaying of the cables, and torn loose by the unusual violence of the east-northeast storm of February 2. Flying fragments of ice made travel dangerous in the vicinity of the radio station and the Weather Bureau station throughout that day and night; and the fragments broke all the easterly windows in the Weather Bureau building. The barograph record shows false rises of 0.04 to 0.10 inch from 4:50 p. m. (when the office window broke) to about 7:30 p. m. when the window was boarded up (see fig. 1).

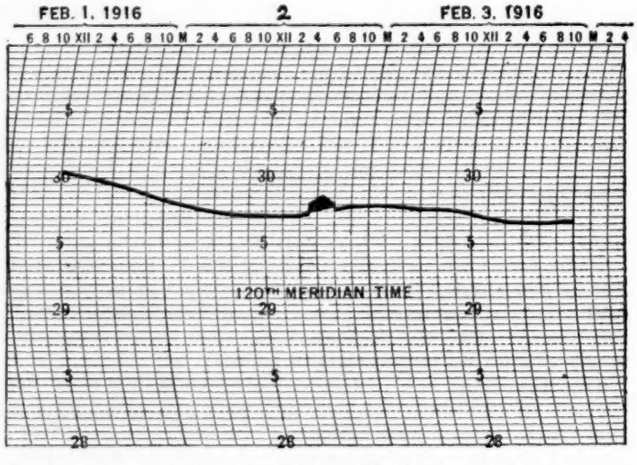


FIG. 1.—Barogram for Feb. 1-3, 1916, at Tatoosh Island, Wash., showing false rises on the 2d (4:50–7:30 p. m.), due to broken window.

[27] *Gregory, J. W.* In The Geographical Journal, London, 1914, **43**: 293–318.

The average wind velocity for February 2 was 68.4 miles, the 5-minute maximum was 88, and the extreme for 1 minute was at the rate of 111 miles per hour. In maximum velocity alone, this storm is tied with the southerly storm of December 17, 1912, for second place and exceeded only by the storm of December 25, 1908. A thorough analysis would show this storm to be in an entirely different class from the other storms mentioned and show that much of the force of the easterly winds is confined to the immediate vicinity of the station. As a matter of fact there is too much difference in the characteristics of the easterly storms and those of the storms from south to northwest to allow of classifying the former according to registered velocity alone. In this discussion winds of more than 60 miles from east-northeast without damage. On the other hand, one vessel, while inbound off Neah Bay, was partially dismasted in a southwest squall of 36 miles. In the latter case the increase in force was too sudden to permit sufficient shortening of sail. In this connection it would appear that the verifying velocity for this station should be greater for the northeast rather than for the southeast wind, as at present.

Much of the force of the easterly wind is apparently local and due to the configuration of the strait. The shoreline on the south side for 5 miles eastward extends almost due east and west. A study of the maxima in east-northeast winds almost invariably shows more of the northerly component in the direction about the times

TABLE 1.—*Hourly wind movements and maximum velocities at Tatoosh Island, Wash.*

Date.		A. M.												P. M.										
		1	2	3	4	5	6	7	8	9	10	11	Noon.	1	2	3	4	5	6	7	8	9	10	11	Midnight.
1916.																									
Feb. 1	Total movement	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(39)	39	43	42)	43	(43 | 42)	49	50	52	53	56
	Maximum velocity	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	48	.....	.....	51	54	54	56	58
Feb. 2	Total movement	56	58	58	53	52	59	59	62	64	66	74	63	79	77	81	81	81	79	78	78	78	73	72	60
	Maximum velocity	60	60	61	60	56	61	62	65	68	72	80	76	84	86	88	85	84	84	82	82	79	76	78	69
Feb. 3	Total movement	55	52	58	53	55	57	54	54	53	53	53	50	47	43	(42)	46	44	(39)	.....	.....	.....	.....	.....	.....
	Maximum velocity	60	58	61	56	59	60	58	58	56	56	57	54	49	48	.....	50	50	.....	.....	.....	.....	.....	.....	.....
1912.																									
Dec. 17	Total movement	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	(14	13	13	18	24)	36	55	64	69	58	47	(43)
	Maximum velocity	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	60	60	74	88	78	54	.....

the southeast wind is not considered as a storm wind, but as the introduction of a south or southwest storm.

This storm in common with all east-northeast storms, increased slowly in violence, maintained its full strength for several hours and gradually diminished, showing characteristics of the monsoon type of wind rather than those of the cyclonic type. The total movement between 11 a. m. and noon of February 1 was 22 miles and the subsequent hourly runs and maxima are given in Table 1. The hourly maxima differed from the total hourly runs by from 2 to 13 miles with an average difference of 4. The average run from noon to 9 p. m. of February 2 was 79, or 9 miles below the maximum; and between 2 and 5 p. m. the average was 81, or 7 below the maximum.

This wind varied only about 10° in either direction from east-northeast, veering toward east while under 65 miles and backing toward northeast with an increase in velocity.

As an illustration of the different types of storm winds from the other directions, similar records of the storm of December 17, 1912, are given at the bottom of Table 1. Here the differences range from 5 to 24 miles, with an average difference of 14 miles, or 3½ times the difference shown in the easterly storm. This ratio is greater than usual, but the variation is constantly exhibited in the same direction. During this storm, with increased rapidity of fall in pressure, the wind shifted from southeast to south, and with a rise in pressure it shifted to the southwest, then diminished in force and shifted to west and northwest, following the ordinary cycle of changes in one of the two general types of storms setting in from the southeast.

Under the influence of an anticyclone, the easterly winds may blow out of the Strait of Juan de Fuca with high velocities for several days at a time, with unclouded skies and otherwise pleasant weather. Masters of sailing vessels gladly take advantage of such weather conditions when outbound, and have completed the run from Puget Sound to San Francisco in five days, or less than half the time of an ordinary smart run. Many vessels have passed out of the strait under full sail before

of their occurrence, suggesting that the increase in speed is induced by lateral compression. There is no means of determining if these winds are stronger between the station and the near-by cape, but the cape's effect in the strait can frequently be noted. During the time on

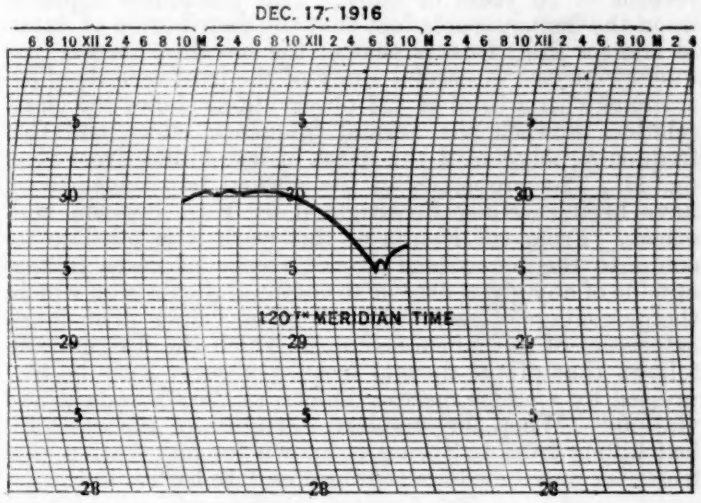


FIG. 2.—Barogram for Dec. 17, 1916, at Tatoosh Island, Wash., characteristic of storms other than easterly at that station.

February 2 when the wind was averaging 80 miles the wind's effect on the water and on four passing steam vessels was observed to be no greater, at distances of 1 mile and more from the station, than that exerted during registered velocities of from 65 to 70 miles an hour from the same direction. Three of the vessels, inbound, made fair time against the wind and apparently were retarded not more than 4 miles an hour.

An important difference between the easterly winds and westerly winds is their respective effect on the waves. The swell is normally propagated from west to east, or on-shore. Any westerly wind tends to heighten the waves. An easterly wind, on the contrary, beats the sea down until a velocity of about 70 miles is attained

after which the wind produces an off-shore wave of comparatively slight intensity.

The general character of the pressure changes in storms other than easterly is shown by the accompanying barograph trace for December 17, 1912 (fig. 2). Further study would be needed to determine the characteristic trace, if any, accompanying the easterlies.

A thorough study of storms of this locality would greatly increase the value of warnings by allowing them to be issued earlier and enabling the correct direction and force to be forecast more frequently. It is also probable that types of pressure changes as shown on the barograph records could be classified and reported by one word in such extent of detail as to be of great value to the forecaster at the district center.

WEATHER AS A BUSINESS RISK IN FARMING.[1]

By WILLIAM GARDNER REED and HOWARD R. TOLLEY.

[*Authors' abstract*, dated: Office of Farm Management, Washington, D. C., July 11, 1916.]

No type of agriculture can be successfully established in a region where the risk of loss by the occurrence of unfavorable weather conditions is not more than balanced by the profits at other times. It is necessary for the farmer's success as a business man to know the risk involved in raising particular crops. Climatic data as usually presented in averages and extremes give a general idea of the character of the region, but show nothing regarding the frequency of departures from the average conditions. The study of the occurrence of dates of last killing frost in Spring and first killing frost in Fall shows that it is possible to determine with a fair degree of accuracy the chance of killing frost after a given date in Spring or before a given date in Fall for places having records of 20 years or more. This possibility depends upon the demonstrable fact that the distribution of dates of last (or first) frost is that of the so-called normal frequency curve. A careful study of the frost records of 33 stations with a total of 823 observations shows the close relation between the normal frequency curve and the frequency polygon of the dates of last killing frost (see fig. 1). The properties of the normal frequency curve have been carefully investigated by Karl Pearson and others. From the results of this work it is possible to compute the percentage of occurrence of cases falling outside of any given date or to compute the date on which the percentage of cases falls to a given value. The characteristics of any phenomenon in which the distribution follows that of the normal frequency curve may be expressed by a single number known as the "standard deviation." When the standard deviation of the dates of last killing frost in Spring is known for any station the frost risk may be computed for any date by Table 1.

TABLE 1.—*Risk of killing frost in spring.*

Risk of occurrence.	Number of days after the average date.	Example, La Crosse, Wis.
Per cent.		
50	Average date	Apr. 26.
40	0.25×standard deviation	Apr. 26+(0.25×14.4)=Apr. 30.
30	0.52×standard deviation	Apr 26+(0.52×14.4)=May 4.
25	0.67×standard deviation	Apr. 26+(0.67×14.4)=May 6.
20	0.84×standard deviation	Apr. 26+(0.84×14.4)=May 9.
10	1.28×standard deviation	Apr. 26+(1.28×14.4)=May 15.

The autumn date when the risk of killing frost rises to a given per cent may be determined by subtracting from the average date the numbers obtained by the use of the standard deviation of the date of first killing frost.

The distribution of frost conditions in the United States is indicated by figures 2 and 3. Figure 2 shows the standard deviations of the dates of last killing frost in Spring. The isograms were drawn from the standard deviations determined for 569 stations fairly well distributed over the country. The lines are of necessity somewhat general. Figure 3 is a similar map of the standard deviations of first killing frost in autumn.

To compute the time available for plant growth in a given proportion of the years the most satisfactory method is that based on the risk at each end of the growing season. If the chance of safety on a given date in Spring is one-half and that on a given date in Fall is one-half, the chance of safety for the whole period between is one-half multiplied by one-half—that is, one-fourth. For many important crops about a four-fifths chance of safety is essential for continued success. A period in which the probability of no killing frost is four-fifths and of which the beginning is definitely known may be determined for any station as follows: Given the standard deviation of the date of last killing frost in spring, the date upon which the chance of killing frost falls to 10 per cent may be determined from Table 1. The date on which the chance of Fall killing frost rises above 10 per cent may be determined from the standard deviation of the dates of first killing frost in Fall and Table 1. Therefore, for any place the length of the available growing season (that is, number of days for which the chance is four in five), beginning at the date when the frost risk falls to 10 per cent, is the number of days between this date and the date on which the chance of fall frost rises to 10 per cent. Although this method of determining business risk is subject to limitations because of the shortness of the individual records, a careful examination of the records shows that in the large the computed dates on which the frost risk rises (or falls) to 10 per cent, when compared with the actual number of occurrences, is a very close agreement. From a total of 27,157 observations the lack of agreement between the computed and counted cases was but 17 in 10,000.

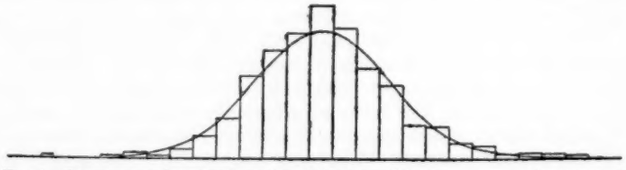


FIG. 1.—Frequency polygon and most probable normal frequency curve of the date of last killing frost in Spring for the combined records of 33 stations, comprising 823 observations.

Statements of risks based upon the results of such a study as this should not be regarded as seasonal forecasts. They simply represent, as far as may be determined from the data now available, the chances the farmer must meet if his business is to be permanently successful. The risks of loss which may profitably be carried varies with the crop and the economic conditions. For those crops in which the early production results in higher prices, e. g., garden vegetables, a considerable risk may be assumed with frequent losses and profit in the long run. In the case of other crops, e. g., corn, early production is of little or no advantage, and the risk which can be assumed is much smaller.

The occasional occurrence of unfavorable weather conditions is a risk which must be recognized by successful farmers. In the case of phenomena whose distribution follows the "normal law of frequency" this risk may be determined with a fair degree of accuracy. The method of determining the risk of frost occurrence has been described in this paper; the distributions of other phenomena seem to be more complicated, but further studies along this line will doubtless result in determining a method of computing the risks from their occurrence.

[1] *See* Geographical Review, New York, July, 1916, 2: 48–53.

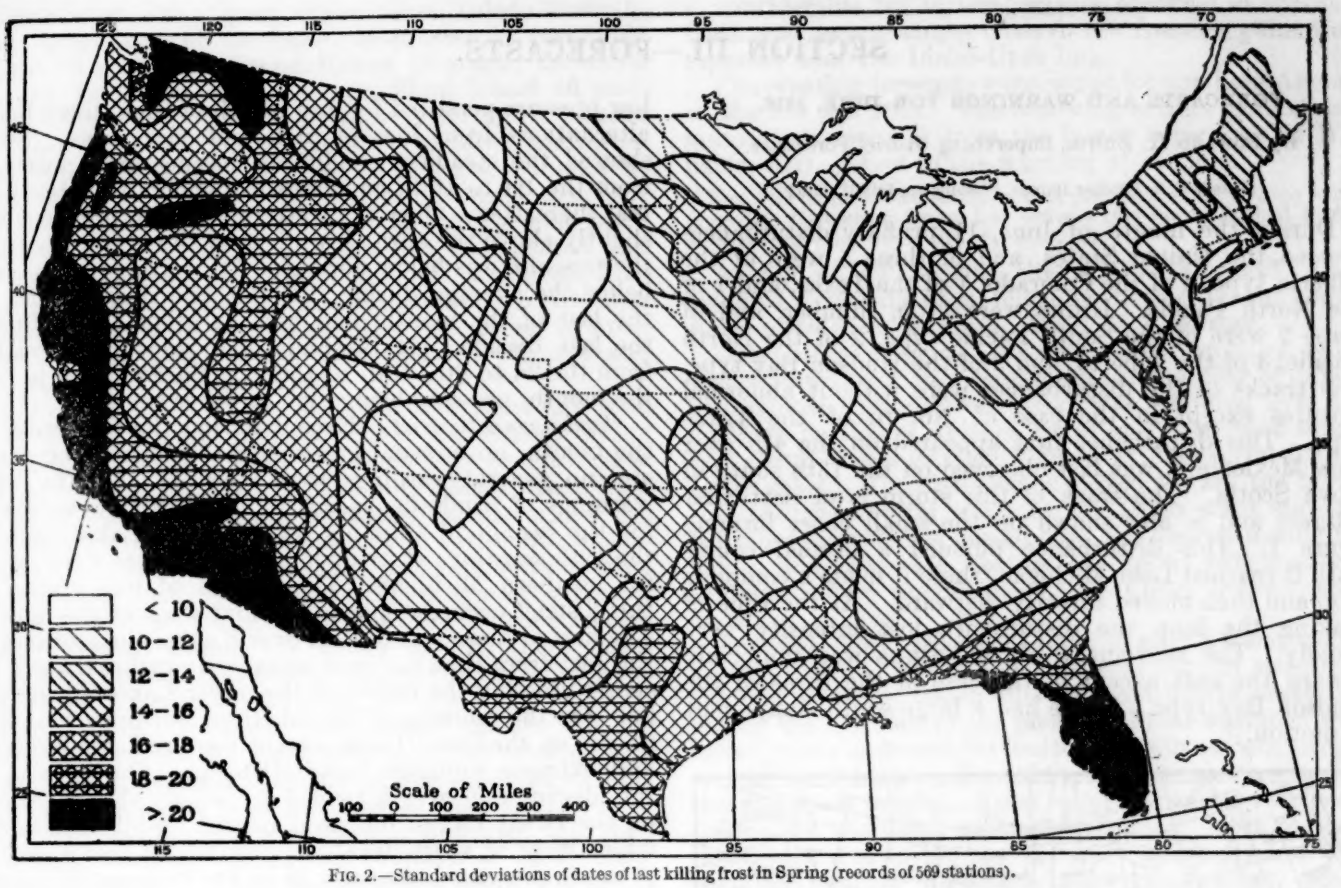


FIG. 2.—Standard deviations of dates of last killing frost in Spring (records of 569 stations).

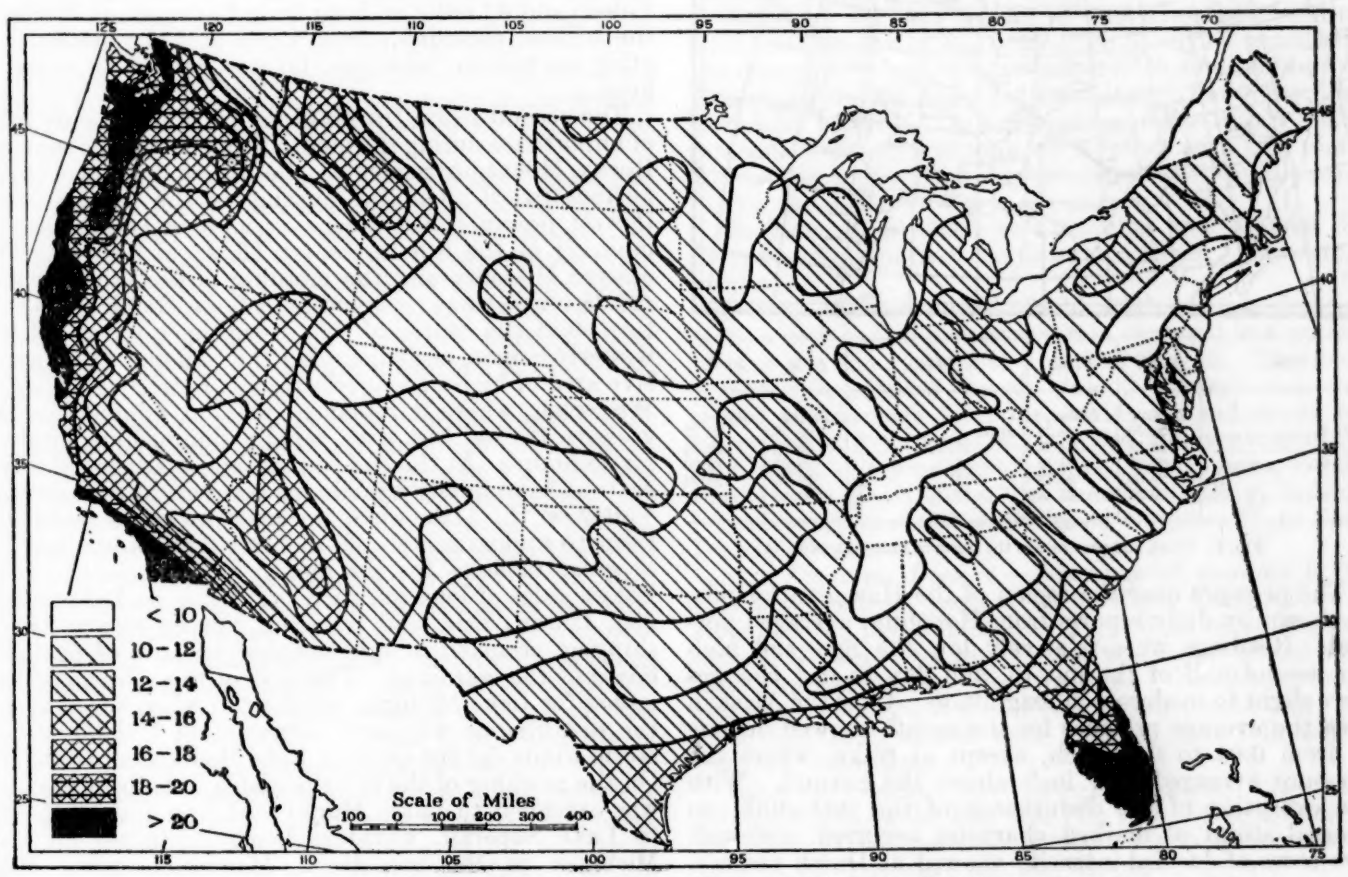


FIG. 3.—Standard deviations of dates of first killing frost in Fall (records of 569 stations).

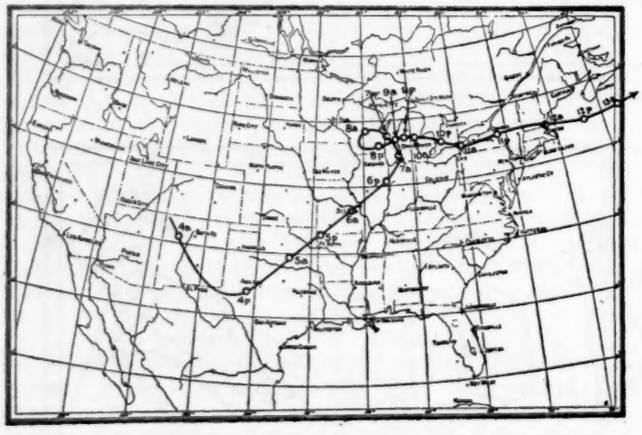
SECTION III.—FORECASTS.

FORECASTS AND WARNINGS FOR JUNE, 1916.

By EDWARD H. BOWIE, Supervising District Forecaster.

[Dated: U. S. Weather Bureau, Washington, July 17, 1916.]

During the month of June, 11 primary disturbances crossed the United States, and of these 5 were of the Alberta type, 4 of the Colorado, 1 of the Texas, and 1 of the North Pacific. HIGHS were 11 in number, and of these 2 were of the South Pacific type, 2 of the North Pacific, 4 of the Alberta, and 3 of the Hudson Bay type. The tracks of the disturbances were without abnormal features except in the case of No. III of the Texas type. This disturbance first appeared on the 4th over New Mexico and was last observed on the 13th south of Nova Scotia. The track of this storm is of particular interest and is also shown on the small chart forming figure 1. This disturbance pursued a normal course until it reached Lake Michigan, there it made a complete loop and then moved directly eastward. At the time of making the loop the disturbance lost intensity very rapidly. The movement of the HIGHS was uniformly toward the east except in the case of the three of the Hudson Bay type. These had a large south component of motion.



Date.	A. M.	P. M.	Date.	A. M.	P. M.
	Inches.	*Inches.*		*Inches.*	*Inches.*
June 4	29.50	29.34	June 9	29.58	29.72
5	29.38	29.28	10	29.80	29.84
6	29.22	29.32	11	29.92	29.96
7	29.30	29.18	12	29.96	29.94
8	29.34	29.46	13	29.90	.....

FIG. 1.—Track and pressures of the storm of June 4–13, 1916.

The pressure over the region of the Hawaiian Islands, as shown by daily reports from Honolulu, averaged normal. Readings were relatively low the first and high the second half of the month, and day to day changes were slight to moderate in magnitude. Over the Alaskan area the average pressure for the month showed deficits of from 0.06 to 0.10 inch, except at Sitka, where the pressure averaged 0.01 inch above the normal. With the exception of the disturbance of the 29th–30th, no general storm of marked character occurred, although two LOWS of decided intensity showed at Dutch Harbor, one on the 8th, and the other about the 13th. Generally speaking, fluctuations were slight and neither high nor low pressure persisted for any length of time, there being alternations from low to high and vice versa. Sitka showed the steadiest conditions, having high pressures from the 1st to 16th, and pressures generally below normal thereafter. Over the western Atlantic pressure was slightly above the normal, while over the eastern portion the pressure was below normal. At Horta pressure was below the average during the first two decades and at the last of the month, and high at other times during the last decade. At Bermuda low pressure prevailed from the 2d to 8th, 13th to 15th, on the 22d, and last of the month, pressure being high at other times.

Washington District.—Except during the first week of the month, no unusual atmospheric conditions occurred and no general warnings were required. On the 14th warnings of winds dangerous to small craft were issued for the benefit of shipping on the Great Lakes, and on the 19th warnings of frosts in exposed places were issued for northern Michigan. The storms of importance in this district occurred during the first week of the month. The first of these was central over Kansas the morning of the 1st; from that region it advanced northeastward, its center crossing the region of the upper Lakes during the 2d. On the morning of the 2d storm warnings were displayed on the Great Lakes except western Lake Superior and extreme southern Lake Michigan. During the 2d this disturbance was attended by strong shifting winds on the Great Lakes, but as it moved rapidly the storm winds were of short duration, despite the fact that the pressure decreased to nearly 29 inches in upper Michigan. Velocities of 46 miles an hour from the southwest at Toledo and 42 miles an hour from the south at Erie were the highest recorded storm winds at Lake stations; all other maximum velocities did not exceed 38 miles an hour.

The second storm (III on Chart II) and the only other of importance during the month formed over the southern Rocky Mountain region on the 4th and thence moved northeastward. On the morning of the 5th its center (lowest pressure 29.38 inches) was over Oklahoma, the morning of the 6th its center (29.22 inches) was over eastern Missouri, and the morning of the 7th its center (29.28 inches) was over southern Lake Michigan. From this point the center of this disturbance advanced in a westerly course, accompanying the building of an extensive area of high pressure in the St. Lawrence Valley, to Wisconsin, where it remained without appreciable progressive motion but with rapidly diminishing intensity for 48 hours. At the end of this time it advanced slowly eastward and finally was dissipated over the St. Lawrence Valley on the 11th, when the pressure at its center had risen to approximately 30 inches. This storm was one of great violence for the month of June on the Great Lakes, gales of long duration prevailing on Lakes Michigan, Huron, Erie, and Superior, but no serious loss of shipping occurred, unquestionably because of the timeliness of the warnings. The first of these warnings was issued for Lake Michigan on the 5th when the center of the disturbance was over northeastern Oklahoma, and storm winds did not set in on Lake Michigan until the 6th. On the morning of the 6th the display of storm warnings was extended to Lakes Huron and Erie and on the 7th to Lake Superior, warnings being continued on Lake Michigan in the meantime. Maximum storm winds occurred on the Great Lakes in connection with this disturbance as follows: 6th, Chicago 46 miles an hour from

the northeast; 7th, Alpena 48 southeast, Toledo 42 southwest, Green Bay 46 northeast, Marquette 44 east, Port Huron 36 southeast, Grand Haven 38 south, Escanaba 40 east, Sault Ste. Marie 36 east, Plum Island 46 east; 8th, Duluth 42 northeast. Moreover, during its passage northeastward from the southern Rocky Mountain region to the upper Lakes this disturbance gave rise to numerous thunderstorms and severe local windstorms over the southern Plains States, the lower Mississippi and lower Ohio Valleys, Tennessee, and the east Gulf States, and tornadoes occurred in parts of Missouri, Arkansas, Mississippi, Illinois, Tennessee, and Kentucky. In Arkansas the tornadoes were very destructive; according to press reports about 200 persons were killed or injured and much property was destroyed.

Chicago District.—Unsettled weather prevailed with more than the usual frequency over the district during the month, and therefore conditions were not favorable for the formation of frost. The only places where frost occurred were the western portion of Montana and the elevated sections of Wyoming early in the month but no damage was possible. The areas, as a rule, were covered by warnings fairly well in advance of the occurrences. No frost of consequence occurred in the Wisconsin cranberry marshes during the entire month, there being observed but two light frosts—one at Cranmoor on June 5 and one at Berlin on the 21st.

Fire-weather warnings were issued on the 2d for northern Montana for fresh winds by the afternoon of the following day, and the warning was repeated on June 3. No information is at hand as to the verification of these forecasts, but the weather map indicated that they were fully verified.—*H. J. Cox, Professor of Meteorology.*

Denver District.—There was a general absence of activity on the part of low pressure areas affecting this district. Some of the low areas remained nearly stationary for days at a time and this feature together with the lack of anticyclonic areas of importance in favorable locations resulted in one of the driest Junes on record in the greater part of the district. At Denver it was next to the driest June on record.

Frost warnings were issued for Colorado, Utah and northern New Mexico on June 2, as an anticyclonic area attended by frost was spreading eastward across the middle Rocky Mountain region. Frost temperatures were recorded in localities in Colorado and Utah on the morning of the 3d. In northern New Mexico, however, the weather became cloudy and somewhat warmer under the influence of a low pressure area that developed in the southern portion of New Mexico.

On the 5th an anticyclonic area over the north Pacific States gave unmistakable indications of moving eastward to the northern Rocky Mountain region and warnings of local frost were issued for Utah. Temperatures fell nearly to 40° in northern Utah on the morning of the 6th, but were above normal in southern Utah under the influence of low pressure that developed in Arizona and New Mexico. Warnings of local frost were issued for Colorado and Utah on the 6th, as the cool anticyclonic area was overspreading the northern Rocky Mountain region as anticipated, and had caused a sharp fall in temperature in the extreme northern portions of Colorado and Utah. Frost temperatures occurred quite generally in Colorado and southern Utah on the morning of June 7. In southwestern Colorado and southern Utah temperatures close to the freezing point were reported. Another threatening anticyclonic area appeared on the north Pacific coast on the 10th and warnings of frost in localities in the extreme northern part of Utah were issued. A considerable fall in temperature occurred in northenr Utah and temperatures close to the freezing point were reported near the Idaho-Utah line.

Fire-weather forecasts were issued for northern Arizona on the 9th and 20th. The following extract from a communication received from the forest supervisor at Williams, Ariz., refers to the warning of the 9th:

> You will be interested to learn that your prediction of high winds proved to be correct, for we had quite a gale blowing all of Friday afternoon, the day your wire was received.

At 8 p. m. on the 20th the wind at Flagstaff, Ariz., attained a velocity of 30 miles per hour from the southwest.—*Frederick W. Brist, Assistant Forecaster.*

New Orleans District.—An area of low pressure which was centered over New Mexico on the morning of June 4 had moved southeastward and was centered over the northern portion of western Texas at 8 p. m., and southeast storm warnings were ordered at 8.30 p. m. for the Texas coast. The disturbance moved toward the northeast and gave storm winds at the Texas coast stations. No other disturbance passed over the district during the month and moderate weather conditions with scattered thundershowers prevailed.—*I. M. Cline, District Forecaster.*

Portland, Oreg., District.—June, usually a quiet month in this district, was noted this year for its unsettled, showery weather, which characterized nearly every day during the last half of the month. Frost warnings were issued on six occasions for limited areas in eastern Oregon and southern Idaho. Five of these warnings were verified and one was a failure. Frost formed at one or two localities on six mornings without warnings. Most of these frosts were due to the prevalence of unusually low temperatures during unsettled, showery weather, which temporarily cleared just at sunrise.

Warnings for the benefit of the live-stock industry were sent on the morning of June 8. They announced the change to much cooler weather with some rain in the mountains during the next two days. These warnings were fully verified. On the morning of the 10th the same interests were advised that fair weather with cool nights and slowly moderating day temperatures would prevail during the next two days.

On June 30 a small-craft warning was ordered displayed at the mouth of the Columbia River. It was fully verified.

During the afternoon of the 26th severe electrical storms with hail and excessive rain occurred in a number of places in the northeastern part of Oregon. The newspapers called these storms "cloud-bursts," and they stated the damage to crops, buildings, and roads was heavy but no lives were lost. On the 30th a severe storm, also called a "cloudburst" by the newspapers, flooded the "Upper Hay Canyon" in Sherman County, and four persons were drowned in the flood waters—*E. A. Beals, District Forecaster.*

San Francisco District.—Warnings of showers in the extreme northern portion of northern California were issued on the morning of June 29, and an indefinite forecast for showers over that section was issued on the 30th. These appear to have been justified. Northwest storm warnings were ordered at Point Reyes on the 8th, 9th, 19th, and 20th, and in each instance were followed by verifying velocities.

The Forest Service was warned of conditions favorable for forest fires on the 5th, 6th, 7th, 10th, 14th, 15th, 20th, and 21st, in northern California. While the conditions were at no time very intense, the warnings were appreciated.—*G. H. Willson, District Forecaster.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, JUNE, 1916.

By ALFRED J. HENRY, Professor in Charge.

[Dated: River and Flood Division, Weather Bureau, July 31, 1916.]

Local floods occurred on the 1st, in northeastern Iowa, due to torrential rains which fell in connection with Low No. I, Chart III. The following account of the rainstorm and the resulting floods has been prepared by Meteorologist J. H. Spencer, in charge of the Dubuque (Iowa) river district:

The storm in northeast Iowa on June 1, 1916, was one of the most destructive on record in this part of the country, owing to the resulting local floods. Exceptionally heavy rainfall was recorded over the greater part of northeast Iowa, in connection with severe thunderstorms. These storms occurred between 5 p. m. and midnight, and most of the rain fell in less than three hours. At Decorah, Iowa, the amount of rainfall was 3.21 inches, and the time of heaviest fall between 5:30 p. m. and 7 p. m. At Prairie du Chien, Wis., the amount was 4.10 inches, and the time 6 p. m. to 9:30 p. m.

The result of such heavy rainfall in such a short period was that in the more hilly sections of northeast Iowa floods of an exceptionally destructive character occurred. A great volume of water rushed down the steep hillsides into creeks or small rivers, sweeping away bridges, buildings, live stock, etc.

The greatest losses were at Decorah, Fort Atchison, and McGregor, all Iowa towns, but there was hardly a railroad line in northeast Iowa that did not experience damage of some sort. More than 25 large railroad bridges and a large number of county bridges and culverts were damaged or destroyed. The water rushed through the principal street of McGregor, flooding stores and doing great damage.

At Packard, Iowa, a passenger train ran into a washout and 16 persons were killed and many injured.

Damage was so severe to railroad property that normal traffic on some of the branch lines of northeast Iowa was not resumed for six weeks or more. It will, in fact, require many months to complete permanent repairs.

Losses are estimated to be at least $500,000, divided as follows: $250,000 to railroads, roadbed and track, rolling stock and contents, etc.; $150,000 to the various counties visited by the storm—bridges and culverts, chiefly; $100,000 to private individuals—stocks of merchandise, live stock, suspension of business and wages of employees, etc.

Other severe local floods occurred in the watershed of the Chemung and Canisteo rivers of south-central New York and in north-central counties of Pennsylvania. The rains which produced these floods fell on the 16th and 17th, but inasmuch as there is no regular Weather Bureau station in that region, the rainfall was not shown on the daily weather maps; it must have fallen in connection with LOW No. VII of Chart III. Two weeks later heavy rains again visited this region, destroying much of the construction work that had been begun to restore the property damaged by the floods of two weeks previous. Newspaper reports of damage in the Chemung and Canisteo Valleys, also in Potter and Tioga Counties, Pa., place the loss at $375,000. Four persons lost their lives by drowning. As an instance of the heavy local downpours, it is stated that Lake Keuka, of Yates and Steuben Counties in central New York, with a drainage area of about 196 square miles, on June 17 rose 7 inches in 24 hours. The lake itself has an area of approximately 29 square miles. A rise of 7 inches would therefore represent a little more than 413,000,000 cubic feet, or about one-third of a cubic mile of water.

Floods on the Neosho in southeast Kansas.—The Neosho was in flood throughout its entire course in Kansas during the month. In duration the flood was one of the longest on record. Heavy rains fell on the 5th, 6th, and again on the 10th. The fall on the last-named date at five stations in the valley averaged exactly 3 inches, and it was to this sudden downpour, for it all came during the night of June 10–11, that caused the general overflow and the subsequent high water.

While the heaviest losers were the owners of inundated farms with growing crops, the most severe sufferers were the occupants of houses bordering Rock and Elm Creeks, tributary to the Neosho River, in Allen County. The flood water stood at a depth of several feet in many houses, damaging household goods and other property. Crude oil was carried from the adjoining oil fields by the flood, and when the water receded the petroleum was deposited along with silt in houses, on lawns, streets, and farm lands. In the vicinity of Humboldt and Chanute oil and gas operations in the bottom lands were suspended for two weeks. Drillers were unable to work, and pumping plants were forced to shut down. Other losses to the oil industry were caused by the breaking of two pipe lines across the river, cutting off the production from market.

Most of the levees breached by the flood of last September were broken again. On account of washed-out tracks and bridges, passenger traffic on the Missouri, Kansas & Texas and the Missouri Pacific Railways was suspended for several days.

At Emporia, near the confluence of the Cottonwood and Neosho Rivers, the flood stage was exceeded on June 1, which was a continuation of the overflow of May 31. The flood stage was also exceeded on June 8–9, June 12–18, inclusive, and June 21–24, inclusive, making 14 days of inundation of lowlands in that vicinity. The highest stage, 23.5 feet, occurred on June 14 and 15. The greatest loss in that vicinity was the inundation of prospective crops.

At Iola the flood stage was exceeded on 15 days from June 11 to 23, inclusive, and again on June 25–26. The highest water, 4.5 feet above flood stage on June 11, lacked two-tenths of the maximum stage on September 7, 1915, and seven-tenths of a foot of the highest stage recorded at this station on July 10, 1904, the latter being the most extensive flood for which there are reliable records. During June, 1916, the inundation of lowlands for 15 days was 3 days more prolonged but was probably not quite so extensive as during July, 1904. In this part of the river course more than half of the overflowed crops were a total loss, although some of the land will be planted again this season.

The estimated losses due to the floods of the Neosho River and its tributaries during June, 1916, were:

Buildings, factories, municipal plants, highways, bridges	$20,500
Crops which may or may not have been housed	352,000
Prospective crops, 94,650 acres involved	946,500
Live stock or other movable property	10,500
Suspension of business, including wages of employees	70,000

Warnings of the flood were generally issued from 18 to 48 hours in advance of the overflow. On several days previous to the flood notices were given to daily newspapers and published that with the river nearly bank-full, heavy rains would cause destructive overflow of lowlands along the river course.—*H. K. Holcomb, Observer.*

Flood in Mississippi.—Following the flood of April 14 to June 2, another flood occurred in the Mississippi River from below Warsaw, Ill., to Louisiana, Mo., from June 7 to about June 26, 1916.

At Quincy, Ill., the river was at or above the flood stage from June 7 to 22 and the highest was 16.4 feet on June 9 and 10.

At Hannibal, from June 7 to June 26, the highest was 16.9 feet, June 10.

At Louisiana, from June 7 to June 24, the highest was 15.8 feet on June 10.

Advisory warnings were issued on June 6 and flood warnings on June 7 and 8.

Following as it did the long-continued flood of April, May, and early June, this flood caused but little actual damage. No property was destroyed, the damage consisting of a further delay in the planting and cultivation of crops in the bottom lands. The flood continued so late that it was the first of July before the unprotected lands could be plowed, and as a result thousands of acres of this land will grow up in weeds, which would have been planted in corn, had the water receded two weeks earlier.—*B. L. Waldron, Meteorologist.*

Floods in the Arkansas River.—Heavy local downpours on the 5th, Low No. III, Chart III, in the vicinity of Wichita, Kans., caused Chisholm Creek, a tributary of the Arkansas, which passes through Wichita before joining the main stream, to overflow its banks in the northern part of the city, where large areas in the stock yards and adjoining sections were inundated. The situation became critical later in the day, because of a rise that came down the Little Arkansas River, which

joins the main stream a few miles above the city of Wichita. Levees, which had been erected in 1904 as a protection from overflow from the Little Arkansas, held and serious financial loss was averted. The total acreage overflowed from both rivers was about 2,800 and the damage $38,180.

Heavy rainfalls again on the 20th, in connection with low No. VIII, Chart III, caused the overflow of about 300 acres in the sparsely settled districts in the north end of Wichita, and probably 3,000 acres in rural districts, damaging crops to the extent of about $30,000. The total loss in the Wichita district is estimated at $68,180.

The Columbia River flood.—The Columbia River rose steadily from the melting snow in the mountains. Backwater from this stream caused the Willamette River, at Portland, to rise from 14.5 feet on the 1st to 22.7 feet on the 30th, and it was still rising at the latter date. Heretofore the latest date the crest of the Columbia River flow reached Portland was July 1–2, in 1880, while this year the crest will not be reached until even later than in 1880.—*E. A. Beals, District Forecaster.*

The total loss or damage by floods during June, 1916, as enumerated above is $2,642,680.

Loss to railroads in Arkansas during January–February, 1916, not previously reported, $35,941.51.

The usual statistics of floods in the principal rivers and their tributaries follow in six tables.

TABLE 1.—*Floods in the upper Mississippi and tributaries during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Mississippi	Keokuk, Iowa	14.0	7	14	14.2	8–12
Do	Warsaw, Ill.	17.0	7	12	17.0	7–12
Do	Hannibal, Mo.	13.0	1	3	13.6	1
Do	do	13.0	7	26	16.9	10
Do	Louisiana, Mo.	12.0	1	2	13.0	1
Do	do	12.0	7	24	15.8	10
Do	Quincy, Ill.	14.0	7	22	16.4	9–10
Do	Grafton, Ill.	18.0	1	3	20.7	1
Do	do	18.0	9	18	20.0	11–12
Do	St. Louis, Mo.	30.0	.....	.....	29.9	1
Do	Cape Girardeau, Mo.	30.0	2	2	30.1	2
St. Croix	Stillwater, Minn.	11.3	1	9	13.5	1–2
Illinois	La Salle, Ill.	18.0	1	5	18.7	3
Do	do	18.0	8	30	21.4	11, 24
Do	Peoria, Ill.	16.0	11	30	17.4	25–26
Do	Beardstown, Ill.	12.0	1	30	14.4	1

TABLE 2.—*Floods in the Missouri River and tributaries during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Missouri	Blair, Nebr.	15.0	.....	.....	14.5	30
Do	Hermann, Mo.	21.0	8	9	21.1	9
Solomon	Beloit, Kans.	16.0	.....	.....	15.6	15, 21
Smoky Hill	Lindsborg, Kans.	20.0	14	14	21.5	14
Grand	Chillicothe, Mo.	18.0	4	4	18.2	4
Do	do	18.0	7	10	25.6	8
Do	do	18.0	26	26	19.8	26
Osage	Osceola, Mo.	20.0	16	18	22.0	16
Do	Bagnell, Mo.	20.0	.....	.....	19.8	8

TABLE 3.—*Floods in the upper Arkansas River and tributaries during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Arkansas	Wichita, Kans.	4.0	7	7	4.6	7
Do	do	4.0	21	22	5.1	21
Cottonwood	Emporia, Kans.	19.5	1	1	20.7	1
Do	do	19.5	8	9	20.0	9
Do	do	19.5	12	18	23.5	14, 15
Do	do	19.5	21	24	22.6	22
Neosho	Neosho Rapids, Kans.	22.0	16	16	22.0	16
Do	do	22.0	22	23	22.9	22
Do	Le Roy, Kans.	24.0	12	21	27.1	12
Do	do	24.0	24	25	24.5	24
Do	Iola, Kans.	10.0	11	23	14.5	11
Do	do	10.0	25	26	11.0	26
Do	Oswego, Kans.	20.0	13	28	23.1	19
Grand	Fort Gibson, Okla.	22.0	15	15	22.0	15
North Canadian	Reno Junction, Okla	8.0	10	15	13.6	10
Do	do	8.0	18	18	8.1	18

TABLE 4.—*Floods in the Susquehanna River and tributaries during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Susquehanna	Williamsport, Pa.	20.0	17	17	21.0	17
Chemung	Corning, N. Y.	16.0	17	17	18.4	17
Pine Creek	Waterville, Pa.	12.0	17	17	14.0	17
Juniata	Huntingdon, Pa.	14.0	17	17	14.8	17

TABLE 5.—*Floods in the Southern States during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Staunton	Randolph, Va.	21.0	16	16	21.4	16
Roanoke	Weldon, N. C.	30.0	17	18	36.7	17
Santee	Rimini, S. C.	12.0	18	22	12.7	19
Do	Ferguson, S. C.	12.0	20	23	12.4	21, 22
Cape Fear	Elizabethtown, N.C.	20.0	9	10	23.6	10
Do	do	20.0	19	19	20.7	19
West Pearl	Pearl River, La.	13.0	1	1	13.3	1
Trinity	Liberty, Tex.	25.0	1	2	26.4	1
Rio Grande	San Marcial, N. Mex.	11.0	1	30	13.0	16

TABLE 6.—*Floods in the rivers of the Pacific slope during June, 1916.*

River.	Station.	Flood stage.	Above flood stage.		Crest.	
			From—	To—	Stage.	Date.
		Feet.			*Feet.*	
Columbia	Marcus, Wash.	24.0	14	(1)	33.8	30
Do	Wenatchee, Wash.	40.0	22	(1)	46.4	30
Do	The Dalles, Oreg.	40.0	.....	.....	39.9	30
Do	Vancouver, Wash.	15.0	7	(1)	23.6	30
Kootenai	Bonners Ferry, Idaho.	26.0	17	(1)	32.7	22
Pend Oreille	Newport, Wash.	16.0	19	(1)	21.8	30
Clearwater	Kamiah, Idano	12.0	16	20	13.7	19
Willamette	Portland, Oreg.	15.0	8	(1)	22.7	30
San Joaquin	Firebaugh, Cal.	12.0	15	23	12.4	19, 20
Kings	Piedra, Cal.	12.0	6	19	13.1	17
Colorado	Topock, Ariz.	14.0	18	23	14.8	20
Green	Green River, Wyo.	9.0	18	24	10.0	22
Gunnison	Sapinero, Colo.	16.0	4	22	17.4	14

[1] Flood stage continued into July.

SNOW SURVEYS IN BIG COTTONWOOD CANYON, UTAH, 1912 TO 1916.

By H. K. BURTON, Assistant Engineer, Water Supply.

[Received, Washington, D. C., June 21, 1916.]

During the month of April the annual snow survey of this watershed was made under the direction of S. Q. Cannon, city engineer, by the writer assisted by four men. The equipment consisted of alpen stocks for measuring snow depths and snow density tubes for ascertaining the water equivalent. The survey was made in the period from the 17th to the 23d of April, inclusive.

The party left Salt Lake City Monday afternoon, April 17, and stopped that night at Maxfields Lodge. The next day one party made a survey of Mill D, South Fork, and another party made a survey of Mineral Fork, both parties returning to Maxfields Lodge for the night.

Figures 1 and 2 show the location of the points mentioned in this report.

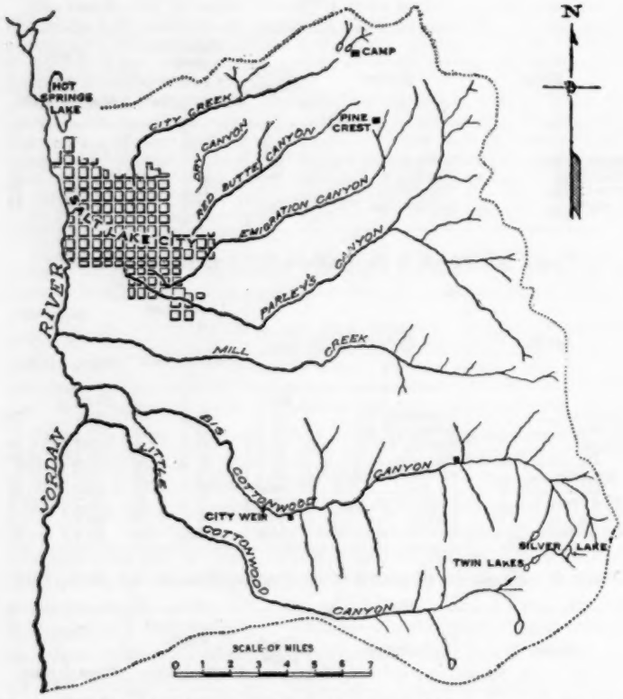


FIG. 1.—Big Cottonwood Canyon and other streams furnishing water to Salt Lake City, Utah.

Wednesday morning the party left the Lodge for Brighton, which is another name for Silver Lake, where it stopped for the remainder of the survey. The trip from the Lodge to Brighton (Silver Lake) was an extremely hard one, as it had snowed practically all night and continued most of the day. About 1 foot of snow fell during the storm. We got our teams only to Mill D, South Fork, and from this point to Brighton (Silver Lake) the trip was made on skis, packing all the supplies and instruments. The new snow made it very hard traveling, the trip from the Lodge to Brighton, about 12 miles, required 12 hours to make. After arriving at Brighton the weather cleared, and the reflection from the snow was intense. From that point surveys were made of all the upper portion of the Big Cottonwood watershed.

Actual measurements were made in Mill D North Fork, Silver Fork, Mill D South Fork, Mill B South Fork, Mineral Fork, Willow Patch, Mill F East Fork, Brighton Basin including the Lake Mary and Twin Lakes areas, and the main canyon from the Forestry Station to Brighton (Silver Lake).

Ninety density measurements and about 300 depth measurements were made.

In the upper part of the watershed where the snow ranged from 8 to 12 feet deep, it was very difficult to make the density measurements, as our tubes were only 74 inches long. The snow had to be dug out with a shovel from 2 to 6 feet in order to get the tube to the bottom, and at depths 4 to 6 feet below the surface of the snow a very hard layer was found, which was almost impossible to penetrate with the tubes. In general the snow was found well packed and drifted. There were numerous snow slides.

The names of the various forks of Big Cottonwood are given on the accompanying figure 2. The areas are named after the forks or creeks, and each one comprises all the area drained by the creek for which it is named.

In Table 1 following are found the names of the areas, with their approximate elevations, the number of the soundings, the average depth of the snow in inches, the water equivalent of the snow, the percentage of density, the acre-feet of water found in each area, and lastly, the area in square miles.

The acre-feet is then computed and the water equivalent averaged for the entire watershed, and these values compared with like values found on surveys for the years 1912 to 1916.

The discharge of the Big Cottonwood is measured at the city weir, and the amount of water passing that weir each season from May 1 to September 30 is compared with the acre-feet of water found on the surveys. The percentage of discharge was often greater than the survey's amount; this was due to the fact that the entire watershed has an area of 48.5 square miles, whereas only 32.41 square miles of the watershed was surveyed. A further discrepancy was caused by the variation in the summer rains.

TABLE 1.—*Snow survey of Big Cottonwood Canyon watershed, Salt Lake City, Utah.*

Location.	Limiting elevations.	Soundings.		Water equivalent.	Snow Density.	Estimated discharge.	Area of survey.
		Number.	Average depth.				
	Feet.		*Inches.*		*Per cent.*	*Acre-feet.*	*Square miles.*
Brads Fork	6,300-9,600	0	[1] 52.73	[1] 19.73	37.42	2,209.76	2.10
Mill B, South Fork	6,640-9,050	11	52.73	19.73	37.42	2,525.44	2.40
Mineral Fork	6,880-8,530	12	40.92	17.36	42.42	1,759.15	1.90
Mill D, South Fork	7,075-9,400	10	60.70	22.44	37.97	6,187.46	5.17
Mill D, North Fork	7,320-8,600	12	50.25	22.79	45.35	3,075.13	2.53
Days Fork	7,470-8,940	0	[1] 60.75	[1] 25.96	42.73	3,129.05	2.26
Silver Fork	7,700-9,500	5	60.80	29.48	48.48	3,333.21	2.12
Willow Patch Fork	7,750-8,850	11	58.36	25.01	42.85	1,827.40	1.37
Mill F, East Fork	8,150-9,250	6	78.67	33.25	42.27	2,837.33	1.60
Main Canyon and Brighton Basin	8,700-9,540	23	79.61	32.37	40.66	11,739.52	6.80
Bear Trap Fork	7,550-8,750	0	[1] 54.31	[1] 23.90	44.01	2,753.28	2.16
North Side Mill B to Mill D	6,700-9,000	0	[1] 30.60	[1] 12.24	40.00	1,305.60	2.00
Total		90				42,682.33	32.41
Average			56.70	24.69	41.80		
Over total watershed, 1916				16.50		42,682.33	48.50
1915				9.53		24,662.7	48.50
1914				15.34		39,674.2	48.50
1913				12.26		31,705.1	48.50
1912				21.50		55,561.0	48.50

[1] Estimated.

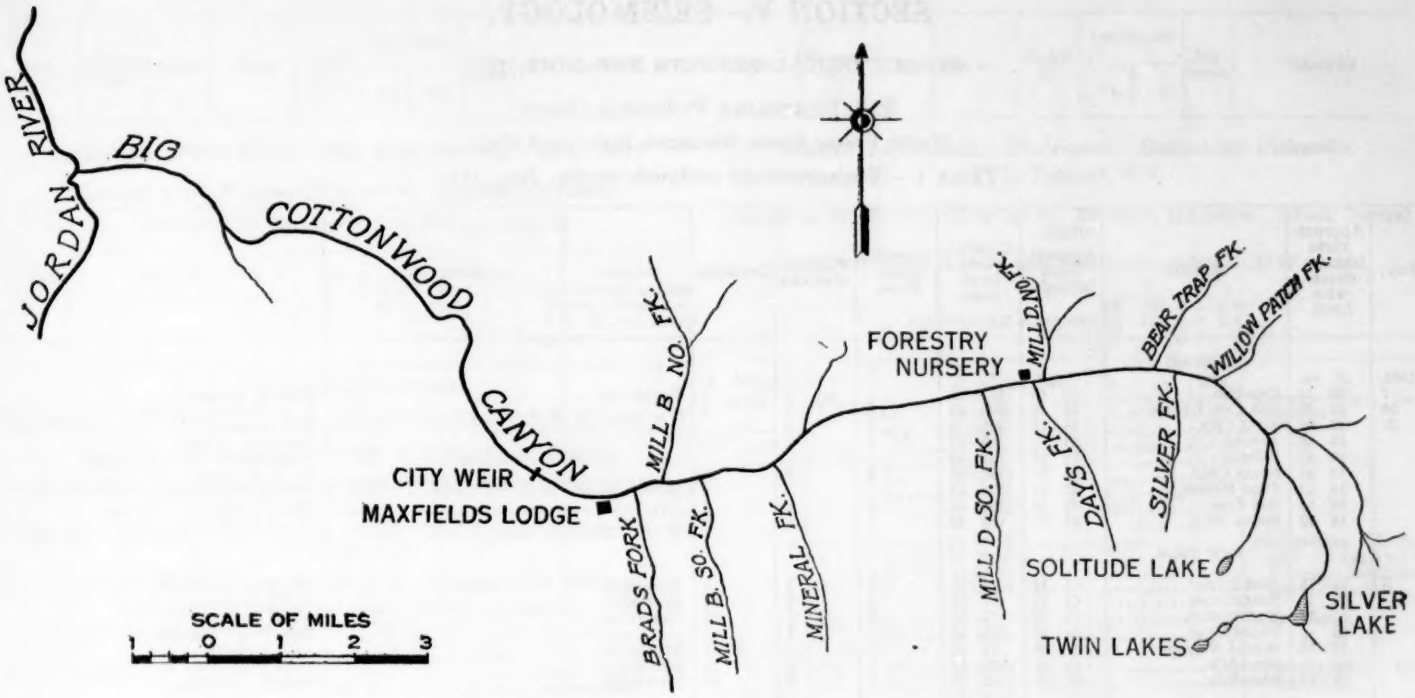


FIG. 2.—Details of Big Cottonwood Canyon, Jordan River, Utah.

TABLE 2.—*Actual discharge measured at City Weir on Big Cottonwood Creek compared with discharge estimated from the snow survey May–September.*

Year.	Discharge.		Weir Snow survey.
	Weir measurement.	Snow survey estimates.	
	Acre-feet.	*Acre-feet.*	*Per cent.*
1912	52,458	55,561	94
1913	36,098	31,705	114
1914	48,500	39,674	122
1915	29,380	24,663	119
1916	.....	42,682	.....

MEAN LAKE LEVELS DURING JUNE, 1916.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., July 5, 1916.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during June, 1916:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	603.48	580.94	573.26	247.86
Above or below—				
Mean stage of May, 1916	+0.48	+0.45	+0.39	+0.73
Mean stage of June, 1915	+1.56	+1.15	+1.41	+2.74
Average stage for June, last 10 years	+1.28	+0.12	+0.41	+0.96
Highest recorded June stage	+0.05	−2.66	−1.26	−0.77
Lowest recorded June stage	+2.24	+1.04	+1.69	+2.97
Average relation of the June level to:				
May level	+0.3	+0.2	+0.1	+0.1
July level	−0.2	±0.0	+0.1	+0.1

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR JUNE, 1916.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Weather Bureau, Washington, D. C., Aug. 3, 1916.]

TABLE 1.—*Noninstrumental earthquake reports, June, 1916.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1916.	*H. m.*		° ′	° ′			*M. s.*			
7	22 15	Calexico	32 40	115 28	3	1	2	Rumbling		Ivan R. Ralston.
26	13 46	San Luis Obispo	35 18	120 39	2	1	2			U. S. Weather Bureau.
27	13 45	King City	36 13	121 06	3	1				F. J. Merritt.
	13 45	Lonoak	36 16	120 58	4	1				Martin L. Griffin.
	13 45	Salinas	36 36	122 40						Ruth Abbott.
	13 45	Santa Cruz	36 56	122 02	3	1	5			W. R. Springer.
	14 15	Paso Robles	35 34	120 40		1	2			Virginia Bartlett.
	14 15	San Jose	37 20	121 54	3	1	5			Maurice Connell.
	14 15	Santa Cruz	36 56	122 02	1	1	2			W. R. Springer.
		NEW YORK.								
8	21 15	Eastchester	41 10	73 45	5	1	15	Rumbling		Mrs. Fred Kuemmel.
	21 15	Eastchester	41 10	73 45	5	2	15	Rumbling		Frank Gorman.
	21 15	Eastchester	41 10	73 45	5	1	15	Rumbling		Alfred Lelash.
	21 15	Eastchester	41 10	73 45		1	15			John Harry Metzler.
	21 15	Mount Vernon	41 08	73 46	3		5 15	Rumbling		J. N. Redway.
	21 15	Scarsdale	41 10	73 45	5	2	15	Rumbling		C. H. Wilmarth.
	21 15	Scarsdale	41 10	73 45	5	2	15	Rumbling		Harold B. Smith.
		SOUTH CAROLINA.								
25	12 05	Charleston	32 47	79 56	2	1	5			Robert Bee.
	12 05	Summerville	33 05	80 14	3	2	2	Rumbling		Miss E. H. Gadsden.
		SOUTH DAKOTA.								
29	7 45	Winner	43 24	99 53	2	1	1 —	Rumbling		Chas. L. Tienken.

TABLE 2.—*Instrumental reports, June, 1916.*

[Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.]

[For significance of symbols see REVIEW for January, 1916, p. 39.]

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. J. W. Green.

Lat. 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E 10 16.7; N 10 15.4}

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 30	.....	e_N	3 41 15	16	.....	.....	.....	Barely preceptible on E.
		M_N	3 44 36	15	.....	50	.....	
		C_N	3 52 20	12	.....	.....	.....	

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat. 32° 14′ 48″ N.; long. 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants: {E 10 16; N 10 19.6}

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	eP	14 03 56	4	.....	.....	.....	End probably occurred while paper was being changed.
		L	14 07 46	5	.....	.....	.....	
		M	14 07 52	5	60	50	.....	
		C	14 15 00	6	.....	.....	.....	
19	.....	e_E	1 33 36	11	.....	.....	.....	
		e_N	1 34 23	7	.....	.....	.....	
		M	.....	.....	10	10	.....	
		F_N	1 36 08	.....	.....	.....	.....	
		F_E	1 41 46	.....	.....	.....	.....	

Arizona. *Tucson*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 21	.....	e	21 52 16	6	.....	.....	.....	
		M	.....	.....	10	10	.....	
		F	21 58 00	.....	.....	.....	.....	
25	.....	L_N	18 25 28	5	.....	.....	.....	
		L_E	18 25 39	10	.....	.....	.....	
		M_E	18 26 00	10	400	.....	.....	
		M_N	18 26 24	8	.....	60	.....	
		C_N	18 31 00	6	.....	.....	.....	
		F_N	18 35 45	5	.....	.....	.....	
30	.....	eP_N	3 12 57	5	.....	.....	.....	
		e_E	3 18 38	10	.....	.....	.....	
		L_N	3 21 21	13	.....	.....	.....	
		L_E	3 21 30	13	.....	.....	.....	
		M_E	3 25 43	13	130	.....	.....	
		M_N	3 26 36	12	.....	90	.....	
		C	3 27 00	12	.....	.....	.....	
		F	3 49 00	11	.....	.....	.....	

California. *Berkeley. University of California.*

Lat. 37° 52′ 16″ N.; long. 122° 15′ 37″ W. Elevation, 85.4 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

California. *Mount Hamilton. Lick Observatory.*

Lat. 37° 20′ 24″ N.; long. 121° 38′ 34″ W. Elevation, 1,281.7 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

TABLE 2.—*Instrumental reports, June, 1916*—Continued.

California. *Point Loma. Raja Yoga Academy.* F. J. Dick.

Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters.

Instrument: Two-component, C. D. West seismoscope.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 1	.....	.....	.....	.....	*200	*100	.....	Light tremors during 24 hours preceding 3 p. m. on dates given.
4	.....	.....	.....	.....	*100	*100	.....	

* Amplitude on instrument.

California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J.

Lat., 37° 26′ 36″ N.; long., 121° 57′ 63″ W. Elevation, 27.43 meters.

(*See* Record of the Seismographic Station, University of Santa Clara.)

Colorado. *Denver. Sacred Heart College. Earthquake Station.* A. W. Forstall, S. J.

Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters.

Instrument: Wiechert 80 kg., astatic, horizontal pendulum.

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	II_{Fi}...	P.....	14 05 00	.....	.....	.....	.....	Second prelim. not discernible.
		L_N....	14 09 00	4–5	.....	1.2	.....	
		L_E....	14 09 00	4–5	3.1	.....	.....	
		M_N....	14 10 00	7	.....	3.1	.....	
		M_E....	14 10 00	7	3.1	.....	.....	
		C.....	14 11 00	10–12	.....	.....	.....	
		F_N....	14 18 00	.....	.....	.....	.....	
		F_E....	14 20 00	.....	.....	.....	.....	
16	.....	.....	.....	.....	.....	.....	.....	Visible waves recurring at intervals during day on both comps.
17	.....	L_N....	6 30 00	.....	.....	.....	.....	Long-period waves on both comps. More distinct on N–S. Possibly Forli quake, Italy.
		F_N....	9 15 00	.....	.....	.....	.....	
19	.....	L_E....	3 00 00	.....	.....	.....	.....	Long period irregular waves recurring on E–W.
		F_E....	11 00 00	.....	.....	.....	.....	
21	.....	L_E....	2 30 00	.....	.....	.....	.....	Long-period sine waves on E–W. recurring between hours marked.
		F_E....	4 00 00	.....	.....	.....	.....	

District of Columbia. *Washington. U. S. Weather Bureau.*

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

Instrumental constants..	*V*	T_0
	110	6

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*
June 2	.....	P.....	14 04 54	.....	.....	.....	.....
		S.....	14 09 24	.....	.....	.....	.....
		L.....	14 14 45	.....	.....	.....	.....
		F.....	14 50 00	.....	.....	.....	.....
19	.....	P.....	1 23 40	.....	.....	.....	.....
		S.....	1 29 40	.....	.....	.....	.....
		L?....	1 35 00	.....	.....	.....	.....
		L.....	1 40 00	14	.....	.....	.....
		F.....	2 00 00	.....	.....	.....	.....
21	.....	P.....	21 42 38	.....	.....	.....	.....
		S.....	21 50 49	.....	.....	.....	.....
		SR....	21 55 25	.....	.....	.....	.....
		L?....	22 01 30	.....	.....	.....	.....
		F.....	22 40 00	.....	.....	.....	.....
25	.....	P_E....	18 27 44	.....	.....	.....	.....
		S?....	18 34 11	.....	.....	.....	.....
		SR_1...	18 37 04	.....	.....	.....	.....
		SR_2...	18 38 20	.....	.....	.....	.....
		L.....	18 40 20	.....	.....	.....	.....
		F.....	19 00 00	.....	.....	.....	.....
30	.....	P.....	3 07 50	.....	.....	.....	.....
		S.....	3 13 20	.....	.....	.....	.....
		SR....	3 16 34	.....	.....	.....	.....
		L.....	3 18 52	.....	.....	.....	.....
		F.....	5 00 00	.....	.....	.....	.....

District of Columbia. *Washington. Georgetown University.* F. L. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

Instrumental constants:		*V*	T_0	ε
	E	165	5.4	2.6
	N	143	5.2	3.4
	Z	*80*	*3.0*	*0*

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	III_F...	e_N.....	13 59 28	.....	.....	.....	.....	Microseisms. No distinct M.
		e_E.....	13 59 29	.....	.....	.....	.....	
		ePE_E...	14 05 13	.....	.....	.....	.....	
		ePE_N...	14 05 14	.....	.....	.....	.....	
		S.....	14 10 32	.....	.....	.....	.....	
		L_N....	14 13 22	8	.....	.....	.....	
		L_E....	14 13 31	9	.....	.....	.....	
		F.....	14 50 00	.....	.....	.....	.....	
6	.....	e.....	21 04 12	.....	.....	.....	.....	Microseisms. Difficult of reading. Possibly mechanical disturbance.
		i_E.....	21 08 19	.....	.....	.....	.....	
		i_N.....	21 08 21	.....	.....	.....	.....	
		F.....	21 22 00	.....	.....	.....	.....	
8	II_F....	e.....	21 14 27	.....	.....	.....	.....	Microseisms.
		F.....	21 20 00	.....	.....	.....	.....	
21	III_F...	eP.....	21 42 39	.....	.....	.....	.....	Microseisms. No distinct M.
		S.....	21 50 48	.....	.....	.....	.....	
		eL_E...	21 58 54	15	.....	.....	.....	
		eL_N...	21 59 12	15	.....	.....	.....	
		F.....	22 15 00	.....	.....	.....	.....	
25	III_F...	e_N.....	18 37 30	.....	.....	.....	.....	S_N and L_N not discernible. No distinct M.
		e_E.....	18 37 45	.....	.....	.....	.....	
		S_E.....	18 40 42	.....	.....	.....	.....	
		L_E....	18 43 10	12	.....	.....	.....	
		F.....	18 50 00	.....	.....	.....	.....	
27	III_F...	e_N.....	13 41 55	.....	.....	.....	.....	E–W simply showed thickening of line.
		S_N?...	13 45 28	.....	.....	.....	.....	
		F.....	14 20 00	.....	.....	.....	.....	
30	I_F.....	ePE_N...	3 07 49	.....	.....	.....	.....	Microseisms. P_E lost. No distinct M. Mainka shows e_E 3^h 7^m 18^s, S_E 3^h 13^m 2^s.
		S_E.....	3 13 47	.....	.....	.....	.....	
		S_N.....	3 13 58	.....	.....	.....	.....	
		eL_E...	3 20 42	.....	.....	.....	.....	
		eL_N...	3 20 49	.....	.....	.....	.....	
		L_N....	3 23 51	15	.....	.....	.....	
		L_E....	3 24 05	20	.....	.....	.....	
		F.....	4 24 00	.....	.....	.....	.....	

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wm. W. Merrymon.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instruments: Milne seismograph of the Seismological Committee of the British Association.

Instrumental constant..	T_0
	18.9

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 1	.....	eL.....	15 03 42	.....	.....	.....	.....	
		M.....	15 08 30	.....	*100	.....	.....	
		C.....	15 10 36	.....	.....	.....	.....	
		F.....	15 16 42	.....	.....	.....	.....	
1	.....	eL.....	23 56 24	.....	.....	.....	.....	
		M.....	24 01 54	.....	*100	.....	.....	
		F.....	24 05 12	.....	.....	.....	.....	
2	.....	eP.....	14 17 06	.....	.....	.....	.....	Phases not well marked.
		eL.....	14 24 12	.....	.....	.....	.....	
		M.....	14 32 00	.....	*200	.....	.....	
		C.....	14 35 00	.....	.....	.....	.....	
		F.....	14 51 00	.....	.....	.....	.....	
2	.....	eL.....	16 43 00	.....	.....	.....	.....	
		M.....	16 46 24	.....	*200	.....	.....	
		F.....	16 54 54	.....	.....	.....	.....	
3	.....	eL.....	5 35 12	.....	.....	.....	.....	
		M.....	5 41 00	.....	*350	.....	.....	
		C.....	5 45 36	.....	.....	.....	.....	
		F.....	5 48 30	.....	.....	.....	.....	
6	.....	P.....	13 36 18	.....	.....	.....	.....	
		S.....	13 43 00	.....	.....	.....	.....	
		L.....	13 46 36	.....	.....	.....	.....	
		M.....	13 49 18	.....	*280	.....	.....	
		C.....	13 54 30	.....	.....	.....	.....	
		F.....	14 27 00	.....	.....	.....	.....	

*Amplitude on instrument.

TABLE 2.—*Instrumental reports, June, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Hawaii. *Honolulu*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 9	.....	L.....	21 58 48	23	*500	.....	.....	
		M.....	22 05 24	.....	.....	.....	.....	
		C.....	22 13 12	.....	.....	.....	.....	
		F.....	22 35 48	.....	.....	.....	.....	
12	.....	eL.....	17 15 18	.....	.....	.....	.....	Resembles a local shock.
		M.....	17 16 24	.....	*200	.....	.....	
		F.....	17 21 48	.....	.....	.....	.....	
15	.....	P.....	11 43 30	.....	.....	.....	.....	
		S.....	11 50 30	.....	.....	.....	.....	
		L.....	12 10 24	28	.....	.....	.....	
		M.....	12 17 06	.....	*500	.....	.....	
		C.....	12 27 48	.....	.....	.....	.....	
		F.....	13 37 06	.....	.....	.....	.....	
19	.....	L.....	1 47 18	26	.....	.....	.....	
		M.....	1 52 00	.....	*600	.....	.....	
		C.....	1 57 06	.....	.....	.....	.....	
		F.....	2 33 48	.....	.....	.....	.....	
21	.....	P.....	21 51 18	.....	.....	.....	.....	
		S.....	22 07 30	.....	.....	.....	.....	
		L.....	22 20 12	23	.....	.....	.....	
		M.....	22 24 36	.....	*800	.....	.....	
		C.....	22 41 24	.....	.....	.....	.....	
		F.....	23 33 42	.....	.....	.....	.....	
24	.....	e.....	7 02 12	.....	.....	.....	.....	Apparently local.
		M.....	7 03 00	.....	*300	.....	.....	
		F.....	7 20 12	.....	.....	.....	.....	
30	.....	P.....	3 22 48	.....	.....	.....	.....	
		S.....	3 28 24	.....	.....	.....	.....	
		L.....	3 36 54	22	.....	.....	.....	
		M.....	3 41 36	.....	*4200	.....	.....	
		C.....	4 03 30	.....	.....	.....	.....	
		F.....	5 53 42	.....	.....	.....	.....	

*Amplitude on instrument.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants.		V	T_0	ϵ
	E	177	3.4	4.0
	N	205	3.4	3.8

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	P.....	14 04 05	2–3	1	5	.....	S not discernible.
		L.....	14 07 55	.....	.....	.....	.....	
		M_N.....	14 08 02	.....	.....	15	.....	
		M_E.....	14 08 51	6–10	8	.....	.....	
		F.....	14 37 00	.....	.....	.....	.....	
25	.....	P.....	18 25 46	.....	.....	.....	.....	
		S.....	18 29 18	.....	.....	.....	.....	
		L_E.....	18 31 05	.....	.....	.....	.....	
		L_N.....	18 31 07	.....	.....	.....	.....	
		M_E.....	18 31 29	4–5	9	.....	.....	
		M_N.....	18 32 33	8–12	.....	7	.....	
		F.....	18 49 00	.....	.....	.....	.....	

Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.

Lat., 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.		V	T_0
	E	10	31
	N	10	29

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 21	.....	e_E.....	21 43 02	3	.....	.....	.....	
		S_E.....	21 50 50	6	.....	.....	.....	
		M_E.....	21 50 55	10	100	.....	.....	
		M_N.....	21 51 06	10	.....	20	.....	
		L_E.....	21 58 00	.....	.....	.....	.....	
		F.....	22 06 00	.....	.....	.....	.....	
25	.....	e.....	18 37 00	10	.....	.....	.....	No distinct phases.
		M_E.....	.....	.....	10	.....	.....	
		M_N.....	.....	.....	.....	10	.....	
		F.....	18 45 00	.....	.....	.....	.....	
30	.....	e_E.....	3 09 06	4	.....	.....	.....	Not shown on N.
		S_E.....	3 13 44	12	.....	.....	.....	
		eL_E.....	3 16 32	16	.....	.....	.....	
		M_E.....	3 27 19	17	90	.....	.....	
		C_E.....	3 30 05	.....	.....	.....	.....	
		F_E.....	4 10 00	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants.		V	T_0	ϵ:1
	E	80	23	0
	N	50	25	4:1

(Report for June, 1916, not received.)

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat. 38° 38′ 15″ N.; long. 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.	V	T_0	ϵ:1
	80	7	5:1

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 21	I_E.....	e.....	21 45 00	.....	.....	.....	.....	
		F.....	22 07 00	.....	.....	.....	.....	
29	I_E.....	eP.....	16 09 00	.....	.....	.....	.....	
		S?.....	16 14 00	.....	.....	.....	.....	
		F.....	16 50 00	.....	.....	.....	.....	

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat. 42° 53′ 02″ N.; long. 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.	V	T_0	ϵ:1
	80	7	5:1

(Report for June, 1916, not received.)

New York. *Fordham. Fordham University.* W. C. Repetti, S. J.

Lat. 40° 51′ 47″ N.; long. 73° 53′ 08″ W. Elevation, 23.9 meters.

Instrument: Wiechert 80 kg.

Instrumental constants.		V	T_0	ϵ
	E	72	7.2	1.5
	N	73	7.2	3.75

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	eP_E.....	14 00 44	.....	.....	.....	.....	
		eP_N.....	14 00 46	.....	.....	.....	.....	
		S_N?.....	14 05 44	.....	.....	.....	.....	
		L_N?.....	14 12 14	.....	.....	.....	.....	
8	.....	iP.....	21 11 11	.....	.....	.....	.....	Felt at Hastings and vicinity.
		M_N.....	21 11 14	.....	.....	36	.....	
		M_E.....	21 11 14	.....	18	.....	.....	
		F_N.....	21 11 52	.....	.....	.....	.....	
25	.....	eL_N.....	18 32 20	.....	.....	.....	.....	
		M_N.....	18 35 42	13	.....	6	.....	
		F_N.....	18 43 17	.....	.....	.....	.....	

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat. 42° 26′ 58″ N.; long. 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration.)

Instrumental constants.		V	T_0	ϵ
	E	13	22	4:1
	N	14	25	4:1

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	eP_N.....	14 05 24	6	.....	.....	.....	
		eP_E.....	14 05 28	6	.....	.....	.....	
		S_E.....	14 10 15	7	.....	.....	.....	
		S_N.....	14 10 19	8	.....	.....	.....	
		F_N.....	14 25 00	.....	.....	.....	.....	
		F_E.....	14 27 00	.....	.....	.....	.....	
21	.....	P_N.....	21 42 15	6	.....	.....	.....	E–W time recorder out of order.
		?.....	21 44 10	4	.....	.....	.....	
		S_N.....	21 50 40	9	.....	.....	.....	
		eL_N.....	21 58 48	16	.....	.....	.....	
		F_N.....	22 23 00	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, June, 1916*—Continued.

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
New York. *Ithaca*—Continued.								
1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 25	.....	e_N	18 37 40	25	.....	.....	.....	Phases obscure.
		e_E	18 37 52	4	.....	.....	.....	
		M_N	18 38 33	12	.....	36	.....	
		F_N	18 49 00	.....	.....	.....	.....	
		F_E	18 50 00	.....	.....	.....	.....	
30	.....	e_N	3 09 07	8	.....	.....	.....	
		e_E	3 13 49	18	.....	.....	.....	
		$?_N$	3 13 58	13	.....	.....	.....	
		$?_E$	3 16 59	12	.....	.....	.....	
		F_N	4 10 00	.....	.....	.....	.....	
		F_E	4 11 00	.....	.....	.....	.....	

Panama Canal Zone. *Balboa Heights.* Isthmian Canal Commission.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori 100 kg.

Instrumental constants..	V	T_0
	10	20

(Report for June, 1916, not received.)

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. H. M. Pease.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants...	V	T_0
E	10	21.4
N	10	21.1

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 21	.....	e_N	21 40 17	.....	.....	.....	.....	Ending uncertain because of microseisms or wind tremors.
		S_E	21 45 58	.....	.....	.....	.....	
		S_N	21 46 09	.....	.....	.....	.....	
		L_E	21 48 52	.....	.....	.....	.....	
		L_N	21 49 34	.....	.....	.....	.....	
		M	21 49 50	.....	50	20	.....	
		C	21 55 00	.....	.....	.....	.....	
30	.....	e_E	3 05 42	.....	.....	.....	.....	Beginning and end uncertain on N.
		L_N	3 09 26	16	.....	.....	.....	
		L_E	3 09 54	20	.....	.....	.....	
		M_N	3 09 54	16	.....	100	.....	
		M_E	3 10 16	16	120	.....	.....	
		C	3 14 00	.....	.....	.....	.....	
		F_N	3 24 00	.....	.....	.....	.....	
		F_E	3 28 00	.....	.....	.....	.....	

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants..	V	T_0
E	10	15
N	10	16

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
June 2	.....	P	14 05 47	.....	.....	.....	.....	
		S	14 10 27	.....	.....	.....	.....	
		L?	14 16 05	.....	.....	.....	.....	
		F	14 35 00	.....	.....	.....	.....	
21	.....	P	21 42 33	.....	.....	.....	.....	
		S	21 51 24	.....	.....	.....	.....	
		SR	21 55 05	.....	.....	.....	.....	
		L	21 59 40	.....	.....	.....	.....	
		F?	.....	.....	.....	.....	.....	Artificially disturbed.
25	.....	SR	18 37 30	.....	.....	.....	.....	
		L	18 40 33	.....	.....	.....	.....	
		F	19 00 00	.....	.....	.....	.....	
30	.....	P	3 07 37	.....	.....	.....	.....	
		S?	3 13 00	.....	.....	.....	.....	
		SR	3 15 08	.....	.....	.....	.....	
		L	3 18 35	.....	.....	.....	.....	
		F	4 20 00	.....	.....	.....	.....	

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants:	V	T_0
	120	26

(Report for June, 1916, received too late.)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant..	T_0
	18.

Pillar deviation, 1 mm. swing of boom=0.59″.

(Report for June, 1916, not received.)

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian.

Instrumental constant..	T_0
	18.

Pillar deviation, 1 mm. swing of boom=0.54″.

(Report for June, 1916, not received.)

TABLE 3.—*Late seismological reports.* (*Instrumental.*)

Date.	Character.	Phase.	Time.	Period T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants..	V	T_0	ϵ
E	177	3.4	4.0
N	205	3.4	3.8

1916.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Feb. 2	.....	P_E?	5 05 31	.....	.....	.....	.....	S not discernible.
		L_N	5 10 25	.....	.....	.....	.....	
		M_N	5 10 50	4–5	.....	4	.....	
		M_E	5 13 38	6–7	2	.....	.....	
		F	5 32 00	.....	.....	.....	.....	

SEISMOLOGICAL DISPATCHES.[1]

Mobile, Ala., June 3, 1916.

Earthquake tremors apparently about 900 miles distant were recorded on the seismograph at Spring Hill College here yesterday. (Assoc. Press.)

New York Times, June 9, 1916.

A seismical disturbance was felt in the Hudson Valley in the vicinity of Hastings for several minutes shortly after 4 o'clock yesterday afternoon.

While imperceptible in Manhattan, the tremor was noticed at many points in Westchester County. It was described as a heavy rumble like the report from an underground explosion. The vibration lasted about two minutes. (Local dispatch.)

Rome, June 16, 1916, via Paris, 2.30 p. m.

A heavy earthshock was reported at 3.25 o'clock this morning at Forli, a town of central Italy, having a population of 50,000, and at Rimini, a town with the same number of persons, 28 miles farther east. There were no casualties. (Assoc. Press.)

Rome, June 27, 1916.

Mount Vesuvius is violently active to-night. Dense columns of smoke are rising from newly formed craters of the historic volcano.

Mount Stromboli, in Sicily, also is active. The mouth of the mountain is emitting streams of incandescent lava. (Assoc. Press.)

[1] Reported by the organization indicated and collected by the seismological station at Georgetown University.

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological and seismological work and studies:

Anfossi, Giovanni.
Per la misura delle precipitazioni in montagna. 7 p. 32 cm. (Estratto da "l'Elettrotecnica," giornale ed atti dell'Associazione elettrotecnica italiana, 15 aprile 1915, anno 2, n°. 11.)

Batavia. K. Magnetisch en Meteorologisch observatorium.
Regenwaarnemingen in Nederlandsch-Indië, 36 jaargang, 1914. Batavia. 1915. 2 v. 26½ cm.

Birge, Edward A.
The heat budgets of American and European lakes. (*In* Wisconsin academy of sciences, arts, and letters. Transactions. Madison. 1915. v. 18, pt. 1, p. 166–213.)

British Guiana. Department of science and agriculture.
Report on meteorology for the calendar year 1914. n. p. [1915.] 14 p. 34 cm.

Colombo observatory.
Memoirs. No. 1. On the intensity of rainfall experienced in Ceylon. By A. J. Bamford. Colombo. 1914. 7 p. 3 pl. 33½ cm.
Memoirs. No. 2. Summary of barometric observations, 1870–1913. By A. J. Bamford. Colombo. 1914. 8 p. 33½ cm.

Croydon natural history and scientific society.
Report of the Meteorological committee, 1915. (*In* Proceedings & transactions of the Society. Croydon. 1915/16. v. 8, pt. 2, p. 97 ffg.)

Denmark. Meteorologiske Institut.
Nautisk meteorologisk Aarbog. Nautical meteorological annual. 1915. In Danish and English. Kjøbenhavn. 1916. L, 169 p. plates. 31 cm.

Fox, John A.
Mississippi River flood problem. How the floods can be prevented. [Memphis.] 1915. 63 p. 31½ cm. (Prepared by the Mississippi River levee association.)

Gallé, P. H.
On the relation between fluctuations in the strength of the trade winds of the North-Atlantic Ocean in summer and departures from the normal of the winter temperature in Europe. 14 p. plate. 26½ cm. (*Reprinted from:* K. Akad. van wetenschappen te Amsterdam, Proceedings, v. 18, n°. 9.)

Geneva. Observatoire.
Observations météorologiques faites aux fortifications de Saint-Maurice pendant l'année 1914. Résumé par Raoul Gautier et Ernest Rod. Genève. 1915. 56 p. 22½ cm. (Extrait des Archives des sciences physique et naturelles, nov. 1914, mars, avril, juin et déc. 1915.)
Résumé météorologique de l'année 1914 pour Genève et le Grand Saint-Bernard, par Raoul Gautier. Genève. 1915. 104 p. 22½ cm. (Tiré des Archives des sciences de la Bibliothèque universelle, août et sept. 1915.)

Great Britain. Meteorological office.
The marine observer's handbook. London. 1915. iv, 139 p. plates. 23½ cm. (M. O. 218.)

Hall, Maxwell.
Notes of hurricanes, earthquakes, and other physical occurrences in Jamaica up to the commencement of the Weather service, 1880, with brief notes in continuation to the end of 1915. Kingston. 1916. 8 p. 33½ cm. ([Jamaica. Meteorological service. Publication] no. 455.)

Havana. Observatorio del Colegio de Belén.
[Observaciones meteorológicas.] Año de 1915. Habana. 1916. 3 p. l., 15 p. tables. 36½ cm.

International catalogue of scientific literature.
F. Meteorology. 13th annual issue. London. 1916. viii, 137 p. 22½ cm. (Published for the International council by the Royal society of London.)

Lee, Frederic S., & Scott, Ernest L.
The action of temperature and humidity on the working power of muscle and on the sugar of the blood. p. 486–501. 26 cm. (Reprinted from the American journal of physiology, v. 40, May, 1916.)

Mississippi River commission.
Stages of the Mississippi River and its principal tributaries, for 1915. St. Louis. 1916. lxv, 79 p. 23 cm.

Mitchell, A[lexander] J.
Florida summers and elsewhere. (*In* Florida farmer and home-seeker. Jacksonville. July, 1916. p. 197.)

Mizusawa. International latitude observatory.
Annual report of the meteorological and the seismological observations for the year 1915. Mizusawa. 1916. 43 p. 30 cm.

Mysore. Meteorological department.
Meteorology in Mysore for 1914. 22d annual report. By N. Venkatesa Iyengar. Bangalore. 1916. xi, 56 p. plate. 31 cm.

Netherlands. K. Meteorologisch instituut.
Jaarboek. Annuaire. 66 jaargang. 1914. A & B. [In Dutch and French.] Utrecht. 1915. 2 pts. 32½ cm. ([Pub.] nos. 97 & 98.)
Oceanographische en meteorologische waarnemingen in den Indischen Oceaan. September, October, November (1856–1914). Tabellen & kaarten. [In Dutch and French.] Utrecht. 1915. xi, 240 p. & atlas of 25 pl. 33 cm., atlas 37 x 57 cm. ([Pub.] no. 104.)
Onweders, optische verschijnselen, enz., in Nederland, 1913, deel 34. Amsterdam. 1915. 133 p. plate. 23½ cm. ([Pub.] no. 81.)

Norway. Meteorologiske institut.
Aarsberetning, for budgetaaret 1. juli 1914 til 30. juni 1915. Utgit av N. J. Føyn. Kristiania. 1915. 9 p. 22½ cm.
Jahrbuch für 1915. Kristiania. 1916. xi, 140 p. 33 cm.
Nedbøriagttagelser i Norge. Aargang 21, 1915. Kristiania. [1916.] xi, 66 p. map. 37½ cm.

Osaka meteorological observatory.
Annual report for the year 1915. Part 1. Meteorological observations in Osaka, 1915. Osaka. 1916. 6, 139 p. plates. 26 cm.

Robinson, Edward Van Dyke.
Early economic conditions and the development of agriculture in Minnesota. Minneapolis. 1915. v, 306 p. 34½ cm. (University of Minnesota. Studies in the social sciences, no. 3.) [Climate of Minnesota, p. 11–26.]

Roper, D. W.
Studies in lightning protection on 4,000-volt circuits. p. 817–855. 23 cm. (Presented at the 33d annual convention of the American institute of electrical engineers, Cleveland, O., June 27–30, 1916. Subject to final revision for the Transactions.)

Spafford, Russell R.
The effect of climate and soil upon agriculture. 23 p. 23½ cm. (Reprinted from the University studies, Lincoln, Nebraska, 1916.)

Suen, S. T.
The causes of rainfall and floods in China. (*In* The Chinese students' monthly. Ithaca, N. Y. March, 1915. v. 10, p. 365–377.) [Abstract in this REVIEW, p. 298.]

Talman, Charles Fitzhugh.
The weather. (*In* the Mentor. New York. July 1, 1916. Serial no. 110, p. 1–11.) [Accompanied by 6 photogravures, each bearing on its reverse side a meteorological monograph prepared by the editorial staff of the Mentor association.]

Townsend, C[urtis] McD.
The currents of Lake Michigan and their influence on the climate of the neighboring states. (*In* Journal of the Western society of engineers. Chicago. April, 1916. v. 21, p. 293–309. plate.)

U. S. House of representative. Committee on flood control.
Hearings . . . on floods of the lower Mississippi River. March 8–15, 1916. Washington. 1916. 373 p. 23 cm.
Hearings . . . on floods of the Sacramento River. April 5, 1916. Washington. 1916. 57 p. map. 23 cm.
Hearings . . . on [the Newlands-Broussard-Rainey river regulation bill] to provide for flood prevention and mitigation, and for the storage of flood waters, [etc.] March 31, April 1–4, 1916. Washington. 1916. 2 pts. 23 cm.

Upsala. Observatoire météorologique de l'Université.
Bulletin mensuel. v. 47, année 1915. Upsala. 1915–16. 74 p. 34 cm.

Walker, Gilbert T.
Memorandum regarding the probable amount of monsoon rainfall in 1916. Simla. 1916. 3 p. 33½ cm. [Published by the Indian meteorological department.]

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The subjoined titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of the meteorological contents of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

American journal of science. New Haven. v. 42. July, 1916.
Arctowski, Henryk. The pleionian cycle of climatic fluctuations. p. 27–33.

Canada. Department of agriculture. Bulletin of foreign agricultural intelligence. Ottawa. May, 1916.
Broounoff, P. Crops and the weather. Monograph on the adaptation of farmers to climatic conditions. p. 373–402.

Electrical world. New York. v. 68. July 15, 1916.
Roper, D. W. Lightning protection on 4,000-volt circuits . . . p. 127–129. [Abstract.]

Geographical review. New York. v. 2. July, 1916.
Reed, William Gardner & Tolley, Howard R. Weather as a business risk in farming. p. 48–53. [See this REVIEW, p. 354.]

Harvard college. Astronomical observatory. Annals. v. 73. pt. 3. 1916.
McAdie, Alexander. The winds of Boston and vicinity. p. 211–231.

Japan. Central meteorological observatory. Bulletin. Tokyo. v. 2. no. 4. 1916.
Fujiwhara, S. On the abnormal propagation of sound waves in the atmosphere. Second part. p. 1–82. [See later issue of this REVIEW.]

Nature. London. v. 97. 1916.
Shaw, Napier. Dr. R. H. Scott, F. R. S. p. 365–366. (June 29.) [Obituary.]
Davison, C. The propagation of sound by the atmosphere. p. 402–403. (July 13.)
Shaw, Napier. Prince Boris Galitzine, For. mem. R. S. p. 424. (July 20.) [Obituary.]

Royal society. Proceedings. London. ser. A. v. 92. no. A–642.
Nichols, E. H. Investigation of atmospheric electrical variations at sunrise and sunset. p. 401–408.

Scientific American. New York. v. 115. July 15, 1916.
Volunteer weather observers. p. 56.

Scientific American supplement. New York. v. 83. 1916.
Norton, John F. Modern air. Facts relating to air and ventilation in relation to health. p. 10. (July 1.)
McAdie, Alexander. Aerography. The science of the structure of the atmosphere. p. 20–21. (July 8.) [Repr. from Geographical review.]
Klotz, Otto. Aurora, earth currents, and magnetic disturbances. p. 42–43. (July 15.) [Repr. J. Roy. astron. soc. Canada.]

Scottish geographical magazine. Edinburgh. v. 32. July, 1916.
Obituary: Professor A. Woeikoff. p. 340.

Smithsonian institution. Annual report. Washington. 1915.
Mancini, Ernesto. The earthquake in the Marsica, central Italy. p. 215–218.

Tycos-Rochester. Rochester. v. 6. July, 1916.
Clayton, H. Helm. World meteorology. Weather variations over the earth's surface generally connected and their relation to food supply and to business conditions very marked. p. 7–13.

U. S. States relations service. Experiment station record. Washington. v. 34. June, 1916.
Decarie, J. L. Climatology [of Quebec]. p. 715. [Abstract.]

Victoria. Department of agriculture. Journal. Melbourne. v. 14. January, 1916.
Richardson, A. E. V. Relationship between the average wheat yield and the winter rainfall. p. 37–40.

Académie des sciences. Comptes rendus. Paris. Tome 162. 1916.
Bigourdan, G[uillaume]. Sur la propagation du son à grande distance dans l'atmosphère libre. p. 928–930. (19 juin.)
Galitzine, B[oris]. Sur la localisation de l'épicentre d'un tremblement de terre. p. 954–956. (19 juin.)
Bigourdan, G[uillaume]. Sur la propagation du son à grande distance. p. 965–966. (26 juin.)

Académie des sciences. Comptes rendus. Paris. Tome 163. 3 juillet 1916.
Nodon, Albert. Observations sur des perturbations électromagnétiques terrestres. p. 14–15.

Annales de physique. Paris. 9 série. t. 5. Mars-avril 1916.
Gouy, G. Sur l'état variable des mélanges gazeux soumis à la pesanteur, avec des applicationes aux atmosphères de la terre et du soleil. p. 121–130.

Géographie. Paris. t. 30. Novembre 1915.
Hubert, Henry. Les séismes en Afrique occidentale française. p. 359–364.

Nature. Paris. 44 année. 8 juillet 1916.
Bigourdan, [Guillaume]. Distribution mensuelle de la nébulosité moyenne en France. p. 27–29. With charts of monthly cloudiness.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

THE WEATHER OF THE MONTH.

P. C. DAY, Climatologist and Chief of Division.

[Dated: Weather Bureau, Washington, Aug. 2, 1916.]

PRESSURE.

The distribution of the mean atmospheric pressure over the United States and Canada and the prevailing direction of the winds are graphically shown on Chart VII, while the average values for the month at the several stations, with the departures from the normal, are shown in Tables I and III.

For the month as a whole the mean barometric pressure was above the normal in Maine and over the Canadian Maritime Provinces, the northern half of the Plains States, and to the westward of the Rockies, except in portions of the far Southwest. For all other sections it was below the normal. The positive departures were generally small, the greatest values appearing in the extreme eastern Canadian Provinces, and the negative departures were likewise not large, the greatest appearing in the region of the Great Lakes.

The month opened with relatively high pressure in most sections east of the Mississippi River and in the far Northwest, while relatively low pressure obtained over the southeast portion of the Plains States. Elsewhere pressure was near the normal. During the next several days the pressure was generally low, except over the north Pacific coast, where it was above the normal. From the 5th to the 11th of the month several well-defined low areas moved slowly across the country, followed by a few days with moderately high pressure over most northern and central sections. This in turn was followed from the 14th to the 22d with pressure below the normal over most of the country. During the remainder of the month the pressure was above the normal during much of the time; at the close, however, relatively low pressure prevailed in the extreme eastern Canadian Provinces and over the far Northwest, while it was above the normal in the Lake region and northern portions of the Rocky Mountain and Plateau districts.

The distribution of the HIGHS and LOWS was generally favorable for westerly and northwesterly winds in the Missouri and upper Mississippi valleys and the southern portion of the New England States, while southerly winds were of greatest frequency from the Ohio Valley and Central Plains States southward. Elsewhere variable winds prevailed.

TEMPERATURE.

The temperature from the 1st to the 12th of the month was below the normal throughout most central, northern, and western portions of the country, including much of the great corn belt, and above the average in most southern districts. It was below freezing at times during this period in the northern Rocky Mountain and at elevated points in the southern Plateau districts; and frost occurred in New York, New England, and northern Minnesota.

From the 13th to the 20th the temperature averaged below the normal in practically all central and eastern sections and on the immediate Pacific coast, while it was above the normal in the Rocky Mountain and Plateau regions and the eastern portions of the Pacific Coast States. During this period both maximum and minimum temperatures were higher than previously recorded during the present season in the Rocky Mountain and Plains regions, but at the same time freezing weather occurred at high elevations in Arizona, and frost was reported from Idaho and eastern Oregon. For the remainder of the month the temperature was below the normal in nearly all central, northern and western States, while it was somewhat above the average in most of the Gulf States. Maximum temperatures above 100° were recorded during this period in western Texas, southern New Mexico, and Arizona, but in most of the Rocky Mountain and Plateau regions they did not reach as high points as earlier in the month. Minimum temperatures at or below freezing occurred in northern Nevada and portions of the northern Rocky Mountain States, and frosts were general in the mountain districts.

For the month as a whole the temperature was above the normal in the southern half of South Carolina and the greater part of Georgia, the western Gulf States, the southern portions of the Rocky Mountain and Plateau regions, and in northwestern Oregon and southwestern Washington. Elsewhere it was below the normal.

PRECIPITATION.

During the first decade of the month there was but little rain west of the Rocky Mountains, but to the eastward precipitation was quite general in most sections, except in the west Gulf region, where practically no rain fell. Heavy falls occurred in northern Oklahoma and central Arkansas, and thence northeastward to the Lake region.

Much unsettled and stormy weather prevailed during the greater part of the second decade, but while showers were widespread, the precipitation was irregularly distributed. Heavy falls occurred in some southeastern States, where rainfall for some time past had been light, and they were also heavy in Oklahoma, Kansas, Nebraska, northern Texas, and locally in many of the more eastern States. Some rain fell on the north Pacific coast and it was heavy in parts of Idaho, but none was recorded in the southern portions of the Rocky Mountain, Plateau, and Pacific Coast States.

The rainfall during the remainder of the month was largely in the form of local showers and thunderstorms. The heaviest fall was in extreme southeastern Louisiana, although large amounts were recorded in central Oklahoma and locally in lower Michigan, northern Indiana, and other eastern sections. No rain fell in most of southern Texas, and nearly all of the central and southern Rocky Mountain and Pacific States were likewise rainless during this period.

For the month as a whole the rainfall was heavy in eastern and southern Kansas, central Oklahoma, southeastern Louisiana, and the central portions of Pennsylvania, Maryland, and Virginia, which was also the case over small areas in Michigan, on the South Carolina coast, and in the western portion of the Florida Peninsula. It was moderate to heavy in many sections from the Mississippi Valley eastward and also along the northern border westward to Montana. Elsewhere it was generally light, and in the far Southwest, including Arizona and Nevada, the southern portions of California and Utah, southwestern Colorado, the western half of New Mexico, and the extreme western portion of Texas little or no rain fell.

GENERAL REMARKS.

For the month as a whole the weather was generally cold and unfavorable for cultivated crops in most northern and central districts, although in many sections pastures, meadows, and winter grains made good progress. The corn crop was quite backward in much of the principal corn belt, but it made satisfactory progress in the more southern sections. The weather was generally favorable for winter wheat, and spring wheat, although somewhat retarded by cold weather during the early part of the month, later made generally satisfactory progress.

During the early part of the month the weather was favorable for the growth of cotton, but later there was a considerable period during which growth was retarded in the northern part of the belt by the unseasonably cool weather, while frequent rains prevented cultivation in many sections. However, during the latter part of the month the higher temperatures were favorable and good progress resulted. Truck crops were backward in many sections, but in the greater part of the country, as the month advanced, these crops made more satisfactory progress. The weather was generally favorable for meadows and pastures, except over the central and southern portion of the Rocky Mountain and Plateau regions where they suffered somewhat from lack of rain. Most fruits progressed favorably in development during the month.

SEVERE LOCAL STORMS.

The following notes of severe storms have been extracted from reports from officials of the Weather Bureau:

Arkansas.—A number of separate tornadoes all moving toward the northeast, visited the central and northern portions of Arkansas during the afternoon of June 5 and early morning of June 6, 1916. Press reports indicate that 83 persons were killed or died from the effects of the storms, and that property losses estimated at $247,000 occurred.

Iowa.—The rain and electrical storm which occurred on the night of June 1, 1916, was one of the most destructive of record in northeastern Iowa. Sixteen persons were killed when a train ran into a washout, and the monetary losses totalled at least $500,000.

Kansas.—During June,1916, severe hailstorms occurred in some of the finest wheat growing countries in the western half of the State and along the Oklahoma line in the eastern part, causing more than a million dollars damage to growing crops. The worst of these storms devastated a strip about 4 miles wide, from Otis, near the east line of Rush County, to Pawnee Rock in the southwest corner of Barton County, a distance of 20 miles. This strip embraces some of the best wheat sections in Barton County and the storm literally mowed the crop down. Leaves were stripped from trees and in some places even the bark was torn off. It was stated on good authority that after the storm it was a common sight to see piles of hailstones from a foot to a foot and a half deep where they had drifted, giving the country an appearance of a drifted mid-winter snow. The damage from this one storm was estimated at between a quarter and a half million dollars.

Kentucky.—Severe local storms on the night of June 5–6, 1916, caused much damage in a number of localities. In Graves County about 500 buildings were blown down and several persons injured. In Scott County several thousand acres of land planted to corn and tobacco were seriously damaged. In Anderson County a severe storm destroyed several barns.

Minnesota.—Severe storms of wind, lightning, and rain, occurred on June 22, 27, 28, and 29, 1916, doing much damage to buildings, crops, and trees, and flooding lowlands. At Beardsley the storm of the 28th was in the form of a tornado, destroying barns, wind mills, and other property. A similar storm was reported at Crookston on the 22d.

Mississippi.—On June 5 and 6 thunderstorms were reported quite generally, accompanied by high winds, and in a few instances the storms developed into destructive tornadoes, the severest of which were confined mainly to Hinds, Smith, and Warren Counties near the south-central part of the State. The most destructive of these storms passed over portions of the city of Jackson, in Hinds County, where about 13 lives were lost, more than 50 persons were injured, and the property loss amounted to about $275,000. The greater part of the loss occurred among the less substantial buildings, mostly cabins, located along the path of the storm, which were completely destroyed. The more substantial buildings generally escaped with the loss of roof or chimneys.

In Warren County a well-defined tornado occurred in which five persons were killed and about 25 injured, with property loss estimated at about $20,000. In Smith County a third tornado was observed in which three persons were injured and property loss estimated at $3,000 resulted. Considerable property losses occurred in other parts of the State from winds attending the storms, but they were not of tornadic character.

Ohio.—Quite a number of storms of marked severity, possibly tornadic in character, occurred in this State during the month. Many reports mentioned the large quantity of hail and the large-sized hailstones. Two of the more severe of these storms occurred on June 2; one in Clermont and Brown Counties, causing the death of 2 people, the destruction of 5 houses, 17 barns, numerous outbuildings, and orchards, with an estimated loss of $15,000 to $25,000. The other occurred in Green County, with 1 person killed and estimated property loss of $100,000.

Average accumulated departures for June, 1916.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	°F.	°F.	°F.	Ins.	Ins.	Ins.	0–10		P. ct.	
New England	60.1	−3.5	− 7.9	4.67	+1.70	−0.50	6.4	+1.2	82	+3
Middle Atlantic	66.8	−3.5	+ 4.4	4.27	+0.60	−0.90	5.8	+0.8	74	+1
South Atlantic	75.7	−0.4	+ 9.2	5.69	+0.10	−8.50	5.7	+0.7	76	−2
Florida Peninsula	80.2	−0.2	− 1.5	1.62	−1.90	−7.80	5.2	0.0	75	−5
East Gulf	78.0	−0.1	+ 6.6	4.03	−0.50	−7.50	5.2	+0.5	74	−1
West Gulf	79.4	−0.4	+ 8.3	2.48	−1.40	−3.20	4.7	+0.4	73	−3
Ohio Valley and Tennessee	69.3	−3.8	− 2.0	6.64	+0.40	−0.50	5.8	+0.8	71	+1
Lower Lakes	62.6	−4.4	− 7.3	4.07	+0.50	+2.10	5.9	+1.0	75	+4
Upper Lakes	58.2	−4.3	− 7.0	5.45	+2.10	+3.30	6.2	+1.1	77	+4
North Dakota	58.9	−4.8	−18.3	3.66	0.00	+0.20	5.8	+0.4	71	+3
Upper Mississippi Valley	66.2	−4.7	− 4.3	4.20	−0.20	+0.70	5.8	+0.8	72	+2
Missouri Valley	67.1	−3.9	− 3.7	4.20	−0.20	−3.00	4.7	−0.2	70	+3
Northern slope	58.8	−3.3	−10.8	2.64	+0.40	−0.40	4.8	0.0	61	+4
Middle slope	70.4	−1.4	+ 0.2	4.27	+1.10	−0.80	4.3	+0.3	62	+2
Southern slope	80.0	+2.9	+16.2	1.19	−1.50	−3.50	3.8	0.0	49	−2
Southern Plateau	74.6	0.0	+ 2.4	0.08	−0.30	+1.30	1.0	−1.0	25	−5
Middle Plateau	64.1	−1.0	+ 0.9	0.11	−0.40	−0.40	2.0	−1.3	30	−8
Northern Plateau	61.2	−3.8	−11.5	1.63	+0.50	+1.40	4.7	−0.1	51	0
North Pacific	57.8	−0.4	− 6.6	1.56	−0.50	−5.60	5.6	+1.0	74	−2
Middle Pacific	60.7	−1.9	+ 1.4	0.54	0.00	+0.10	3.1	−0.4	61	−1
South Pacific	64.4	−1.7	+ 2.2	0.00	−0.10	+4.50	2.8	0.0	68	+2

WEATHER CONDITIONS ON THE NORTH ATLANTIC DURING JUNE, 1915.

The data presented are for June, 1915, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month.

Chart IX (XLIV–71) shows for June, 1915, the averages of pressure, temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian time (Greenwich mean noon), together with the locations and courses of the more severe storms of the month.

PRESSURE.

The distribution of the average pressure for the month as shown on Chart IX was abnormal in many respects. The pressure was unusually high and the gradients weak, as north of the 30th parallel the average barometric readings ranged from 29.96 to 30.13 inches, while under normal conditions the range would be from about 29.80 to 30.30 inches. The Azores HIGH was of less intensity and covered a much larger area than usual, and no well-developed LOW existed in the vicinity of Iceland, although a shallow depression covered a large area in the northern part of the ocean. While the average pressure gradients were remarkably uniform the variation from day to day was quite marked in many localities. In the northern part of the ocean, west of the 20th meridian, the pressure was comparatively low in the first three and the last two days of the month, and high in the middle decade. In the 5-degree square between the 55th and 60th parallels and the 35th and 40th meridians the barometric readings ranged from 29.32 inches on the 1st to 30.37 inches on the 16th, and the variation was nearly as large in the waters adjacent to the Canadian coast. From the 21st to the 24th, in the vicinity of the Bermudas, the pressure was considerably below the average for the month, while during the same period, in the area covered by the Azores high, it was above the average, and the extreme range for the month was about normal.

GALES.

June, as a rule, is comparatively free from gales, and the month under discussion was, taken as a whole, no exception, although in some localities the percentage of gales was slightly above the normal; but in the majority of cases it was below. In the 5-degree square between the 40th and 45th parallels and the 40th and 45th meridians the normal percentage of gales is 7, while during June, 1915, the percentage was 13. The same conditions held true in the square between the 45th and 50th parallels and the 35th and 40th meridians, while in the waters adjacent to Cape Hatteras gales were reported on three days, which is slightly above the normal. The distribution of gales throughout the month, in different portions of the ocean, was very irregular, as north of the 45th parallel most of them occurred in the first part of the month, while south of that line the first decade was remarkably free from winds of gale force, none being reported until after the 15th.

Only one storm track has been plotted on Chart IX, although there were a number of cyclonic disturbances whose paths were too indefinite to show accurately on account of lack of observations or otherwise. On Chart III (XLIII–59, MONTHLY WEATHER REVIEW, June, 1915), a LOW is shown that first appeared on the evening of May 28 in southwestern Arizona. This moved in a nearly easterly direction, and on the morning of June 1 was central over Pensacola, the depression being shallow and the winds light. During the 2d and 3d the disturbance moved to the vicinity of Hatteras, becoming much more pronounced than on the 1st. While the winds on the 2d varied from light to moderate, on the 3d they had increased in velocity, as a number of vessels reported gales of from 40 to 55 miles an hour. The LOW moved in an easterly direction and on the 4th the center was about 5° west of Bermuda; winds of gale force still prevailed along the shore near Hatteras, although the storm area was somewhat less than on the previous day. It continued in its easterly movement and on the 5th the area of low pressure surrounded Bermuda, where the barometer began to rise and the winds abate in force. The LOW then began to fill in, and its position was too uncertain to plot during the next two days, while no trace of it could be seen on the 8th. This track is not shown on Chart IX owing to the uncertainty of its movement after June 2.

From June 9 to 13 a LOW existed in the vicinity of the Gulf of St. Lawrence, although no winds of gale force were reported until the 13th when one vessel near St. Johns, Newfoundland, encountered easterly winds of 50 miles an hour. Fog prevailed over a portion of this area from the 9th to the 11th. On the 14th this LOW was central near latitude 39°, longtiude 49°; the isobars surrounding the center were nearly circular in form and the winds were from light to moderate in force. This depression remained nearly stationary during the next two days, and on the 16th a number of vessels near the 39th parallel and the 52d meridian reported northerly gales.

A LOW of slight intensity and surrounded by light to moderate winds covered a large part of the territory between the 40th and 50th parallels and the 10th and 40th meridians during the period from June 17th to 22d. Bermuda was the center of another slight depression on the 21st which moved in a northerly direction and on the 22d was near latitude 42°, longitude 60°; the barometer fell to 29.46 inches and the force of the wind increased near the center, while fog was reported in the northeast quadrant. The LOW then separated into two sections, and on the 23d one part was central near Halifax, Nova Scotia, and the other near latitude 41°, longitude 48°. Both areas had moved about 5° toward the east by the 24th, and on the 25th only one was within the limits of the chart, this being central near St. Johns, Newfoundland.

The wind was moderate over the entire North Atlantic ocean during the three days from the 23d to the 25th, and fog prevailed during the period off the banks of Newfoundland. A shallow depression covered a large area in the vicinity of the British Isles from the 25th to the 29th, although it varied in extent between those dates. On June 28 a LOW (I on Chart IX) of 29.74 inches was central near latitude 40°, longitude 59°. This was of limited extent and the cyclonic circulation around the center was very marked, although no winds of high velocity were reported. This moved rapidly in an easterly direction and on the 29th was near latitude 42°, longitude 49°; the barometer had fallen to 29.23 inches and the wind increased in force, as several vessels near the center, and southwest of it, reported gales of from 40 to 55 miles. The LOW then curved toward the northeast and on the 30th the approximate center was near latitude 50°, longitude 40°, although it was impossible to plot it accurately on account of lack of observations. The storm

was of limited area, although two vessels about 8 degrees south of the center experienced westerly and southwesterly gales of over 60 miles an hour, which was the highest wind velocity reported during the month. The disturbance continued in its northeasterly course and on July 1 was near latitude 52°, longitude 35°. It had increased in area and decreased in intensity, although winds of 40 miles were still encountered in the south and southwest quadrants. The LOW moved but little after July 1 and on the 2d was fast filling in.

TEMPERATURE.

North of the 20th parallel and west of the 30th meridian the average air temperatures for the month were from 1° to 4° above the normal, the largest positive departures occurring in the waters along the northern European coast and decreasing toward the south. North of the 30th parallel and between the 30th and 55th meridians the departures were, as a rule, slightly negative, although there were some exceptions, and south of the 30th parallel the temperatures seldom varied more than a degree from the normal.

In the waters adjacent to the American coast, between St. John's and northern Florida, the departures ranged from −2° to 0°; while at Key West they were slightly positive, and similar conditions held true in the greater part of the Gulf of Mexico.

The temperature departures for June, 1915, at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coasts were as follows:

	°F.
St. John's, Newfoundland	−2.6
Sydney, C. B. I.	−2.8
Halifax, N. S.	−2.0
Eastport	−1.2
Portland	−3.4
Nantucket	−0.3
New York	−1.9
Washington	−2.1
Norfolk	−3.1
Hatteras	−2.8
Charleston	−0.5
Key West	+0.4
Pensacola	+1.2
New Orleans	+4.2
Galveston	+1.7
Corpus Christi	+1.8

The lowest temperature reported during the month was 36° and occurred on the 3d in the 5-degree square off the coast of Labrador. The highest temperature in this square was 51° on the 26th.

Along the coasts of the British Isles the temperatures varied from 48° to 62°, while in mid-ocean the range was somewhat less. The highest temperature recorded was 84° and occurred on a number of days in the Caribbean Sea.

FOG.

During the period from 1901 to 1906 for the month of June the average percentage of days with fog off the banks of Newfoundland was from 60 to 65 per cent, while in the same region for June, 1915, it was observed on from 10 to 11 days, a percentage of from 30 to 33. Off the island of Nantucket the normal percentage of fog is from 40 to 45, while for the month under discussion it was 23. Along the middle and eastern portion of the northern sailing routes the percentage was slightly below the normal.

PRECIPITATION.

No hail or snow was reported during the month.

Maximum wind velocities, June, 1916.

[Velocities below 50 mi./hour (22.4 m./sec.) are not included here.]

Stations.	Date.	Velocity.	Direction.	Stations.	Date.	Velocity.	Direction.
		Mis./hr.				*Mis./hr.*	
Buffalo, N. Y.	9	58	sw.	Mount Tamalpais, Cal.	21	58	nw.
Cairo, Ill.	18	50	sw.	Do.	22	66	nw.
Canton, N. Y.	18	54	sw.	Do.	23	58	nw.
Charlotte, N. C.	6	64	w.	Do.	24	62	nw.
Do.	20	72	w.	Do.	27	50	nw.
Cheyenne, Wyo.	22	54	w.	Do.	28	52	nw.
Dallas, Tex.	26	55	ne.	New York, N. Y.	2	52	nw.
El Paso, Tex.	4	52	w.	Do.	16	53	se.
Erie, Pa.	21	52	sw.	Do.	22	52	nw.
Grand Forks, N. Dak.	22	70	se.	Norfolk, Va.	21	75	nw.
Hatteras, N. C.	3	64	nw.	North Head, Wash.	30	52	se.
Jacksonville, Fla.	29	50	sw.	Oklahoma, Okla.	14	61	n.
Little Rock, Ark.	5	52	s.	Do.	20	56	ne.
Louisville, Ky.	8	54	w.	Pensacola, Fla.	13	56	s.
Memphis, Tenn.	6	50	sw.	Point Reyes Light, Cal.	3	52	nw.
Milwaukee, Wis.	2	56	se.	Do.	8	67	nw.
Mount Tamalpais, Cal.	4	52	nw.	Do.	9	66	nw.
Do.	5	52	nw.	Do.	19	85	nw.
Do.	7	61	nw.	Do.	20	66	nw.
Do.	8	92	nw.	St. Paul, Minn.	22	56	se.
Do.	9	68	nw.	Savannah, Ga.	7	50	w.
Do.	19	54	nw.	Sioux City, Iowa.	22	60	nw.
Do.	20	56	nw.	Wichita, Kans.	5	52	ne.

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, June, 1916.

Section.	Temperature.								Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.						Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest.	Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.		Ins.	Ins.		Ins.		Ins.
Alabama	77.5	−0.5	Thomasville	100	12	3 stations	50	8†	3.35	−1.10	Robertsdale	8.03	Greensboro	0.90
Arizona	75.0	+0.2	Mohawk	119	15	2 stations	28	1†	0.00	−0.28	Tucson	0.07	98 stations	0.00
Arkansas	75.4	−1.0	2 stations	99	21†	Dutton	43	8	5.15	+1.10	Dutton	9.48	Clarendon	2.64
California	65.2	−3.8	Greenland Ranch	121	15	Tamarack	18	2	0.22	−0.09	Branscomb	3.31	151 stations	0.00
Colorado	60.4	−0.2	Lamar	101	28†	Dillon	14	7	0.47	−0.90	Holyoke	5.62	24 stations	0.00
Florida	79.2	−0.8	Malabar	101	7	2 stations	55	3†	6.27	−0.31	Homestead	13.54	Long Key	0.38
Georgia	77.3	−0.5	2 stations	101	22	Blue Ridge	43	9	4.22	−0.30	Lumber City	8.48	Lisbon	1.59
Hawaii (May)	71.9	.....	2 stations	89	12†	Waimea, Hawaii	47	9	12.15	.....	Hakalau (Mauka), Hawaii.	49.93	3 stations	0.00
Idaho	57.2	−2.0	2 stations	105	16†	2 stations	19	12†	1.43	−0.09	Wallace	4.42	Murtaugh	T.
Illinois	67.2	−4.2	4 stations	97	30	3 stations	43	5†	5.56	+1.50	Du Quoin	9.63	Astoria	1.67
Indiana	66.6	−4.4	Princeton	97	30	Auburn	41	20	6.57	+2.33	Shoals	12.53	Mount Vernon	2.83
Iowa	64.5	−4.6	4 stations	96	30	2 stations	38	18†	3.71	−0.67	Postville	7.96	Gilman	1.41
Kansas	70.3	−2.5	3 stations	103	11	Wallace	34	8	6.26	+2.20	Marion	13.72	Coolidge	1.20
Kentucky	70.1	−2.8	Marion	99	30	4 stations	45	1	4.94	+0.72	Mount Sterling	8.99	Weeksbury	2.88
Louisiana	80.5	+0.5	Angola	105	28	2 stations	52	9†	3.89	−1.32	New Orleans (6)	10.03	Kelly (near)	1.30
Maryland-Delaware	67.2	−2.9	Cumberland, Md	95	26	Oakland, Md	33	1	5.91	+1.68	Emmitsburg, Md	11.74	Public Landing, Md	2.46
Michigan	59.1	−4.3	Cassopolis	90	23	3 stations	28	7†	4.81	+1.72	Iron Mountain	9.57	Howell	2.21
Minnesota	60.2	−4.4	3 stations	93	30	Roseau	28	20	4.96	+1.08	Bird Island	7.56	Warroad	2.32
Mississippi	77.4	−1.3	2 stations	99	22†	Fayette	47	9	4.09	−0.73	Holly Bluff	10.85	Collins	0.01
Missouri	70.0	−3.2	Steffenville	100	30	Marshall (2)	42	8†	6.99	+1.17	Jackson	12.81	Warrenton	2.52
Montana	56.3	−2.9	Thompson Falls	96	17	2 stations	19	1†	4.02	+1.09	Sun River Canyon	11.03	Lima	1.27
Nebraska	65.0	−4.1	Imperial	108	29	2 stations	29	7	3.38	−0.49	Guide Rock	7.03	Hull	0.63
Nevada	62.5	−2.2	Logan	112	16	Paradise Valley	19	21	0.05	−0.48	Vya	0.48	27 stations	0.00
New England	60.6	−4.1	Woodstock, Vt	89	27	Millinocket, Me	26	7	5.02	+1.87	Franklin, N. H	9.04	Presque Isle, Me	2.17
New Jersey	64.7	−4.4	3 stations	87	18†	Charlotteburg	36	2	4.20	+0.37	Highwood	5.99	Vineland	2.22
New Mexico	69.6	+0.6	Artesia	111	26	Vermejo Park	20	5	0.40	−0.71	Ione	3.85	58 stations	0.00
New York	60.8	−3.9	Oneonta	89	2	Indian Lake	27	3	4.73	+1.23	Haskinville	9.60	Albany	2.24
North Carolina	72.2	−1.5	Greensboro	97	19	Banners Elk	38	4	6.44	+1.27	Highlands	11.61	Belhaven	3.20
North Dakota	58.2	−4.9	Granville	92	27	3 stations	29	2†	3.88	+0.44	Forman	6.78	Bismarck	1.50
Ohio	64.7	−4.5	Green	94	30	Wauseon	31	1	4.86	+1.07	Granville	7.34	Wickliffe	1.68
Oklahoma	75.4	−0.9	Weatherford	111	1	Kenton	44	1	6.60	+3.10	Newkirk	15.07	Kenton	1.33
Oregon	58.8	−0.8	Vale	111	17	Crescent	15	10	1.79	+0.16	Government Camp	5.05	Andrews	0.24
Pennsylvania	63.7	−4.1	3 stations	89	24†	West Bingham	28	1	6.14	+2.09	Austin	12.45	Philadelphia	2.83
Porto Rico	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
South Carolina	76.4	−1.2	Blackville	100	22	Mountain Rest	48	9	5.12	+0.09	Charleston	9.75	Calhoun Falls	1.76
South Dakota	61.5	−4.8	3 stations	98	28	Elk Mountain	30	8	4.00	+0.18	Wentworth	6.45	Cottonwood	1.83
Tennessee	72.6	−1.8	Copperhill	99	30	3 stations	42	4†	5.60	+1.26	Perryville	9.50	Bolivar	1.76
Texas	81.7	+1.7	Eagle Pass	115	6	Romero	40	4†	2.17	−0.94	Ringo Crossing	6.86	El Paso	0.00
Utah	62.2	−2.2	St. George	107	16	Scofield	20	2†	0.22	−0.28	Clarkston	1.25	39 stations	0.00
Virginia	69.1	−2.4	Ivor	102	24	Burkes Garden	36	1	6.20	+1.84	Mount Weather	11.43	Norfolk	1.98
Washington	59.5	−1.2	Neppel	108	17	Snyders Ranch	27	6	2.02	+0.31	Landsburg	4.94	Neppel	0.01
West Virginia	65.8	−3.3	Moorefield	94	27	3 stations	35	1	5.42	+0.92	Terra Alta	14.54	Brandywine	2.50
Wisconsin	59.7	−4.9	Lancaster	92	29†	Glen Flora	25	6	6.07	+2.21	Port Edwards	8.69	Whitehall	3.03
Wyoming	55.1	−1.8	2 stations	100	27†	Foxpark	14	7	1.15	−0.68	Soda Butte	4.25	Eden	0.00

† Other dates also.

DESCRIPTION OF TABLES AND CHARTS.

Table I gives the data ordinarily needed for climatological studies for about 158 Weather Bureau stations making simultaneous observations at 8 a. m. and 8 p. m., daily, 75th meridian time, and for about 41 others making only one observation. The altitudes of the instruments above ground are also given.

Table II gives a record of precipitation, the intensity of which at some period of the storm's continuance equaled or exceeded the following rates:

Duration (minutes)	5	10	15	20	25	30	35	40	45	50	60
Rates per hour (inches)	3.00	1.80	1.40	1.20	1.08	1.00	0.94	0.90	0.87	0.84	0.80

It is impracticable to make this table sufficiently wide to accommodate on one line the record of accumulated falls that continue at an excessive rate for several hours. In this case *the record is broken at the end of each 50 minutes*, the accumulated amounts being recorded on successive lines until the successive rate ends.

In cases where no storm of sufficient intensity to entitle it to a place in the full table has occurred the greatest precipitation of any single storm has been given, also the greatest hourly fall during that storm.

The tipping-bucket mechanism is *dismounted* and removed when there is danger of snow or water freezing in the same. Table II records this condition by entering an asterisk (*).

Table III gives, for about 30 stations of the Canadian Meteorological Service, the means of pressure and temperature, total precipitation and depth of snowfall, and the respective departures from normal values except in the case of snowfall.

Chart I.—Hydrographs for several of the principal rivers of the United States.

Chart II.—Tracks of centers of high areas; and

Chart III.—Tracks of centers of low areas. The roman numerals show the chronological order of the centers. The figures within the circles show the days of the month; the letters *a* and *p* indicate, respectively, the observations at 8 a. m. and 8 p. m., 75th meridian time. Within each circle is also given (Chart II) the last three figures of the highest barometric reading or (Chart III) the lowest reading reported at or near the center at that time, and in both cases as reduced to sea level and standard gravity.

Chart IV.—Temperature departures. This chart presents the departures of the monthly mean temperatures from the monthly normals. The normals used in computing the departures were computed for a period of 33 years (1873 to 1905) and are published in Weather Bureau Bulletin "R," Washington, 1908. Stations whose records were too short to justify the preparation of normals in 1908 have been provided with normals as adequate records became available, and all have been reduced to the 33-year interval 1873–1905. The shaded portions of the chart indicate areas of positive departures and unshaded portions indicate areas of negative departures. Generalized lines connect places having approximately equal departures of like sign. This chart of monthly temperature departures in the United States was first published in the MONTHLY WEATHER REVIEW for July, 1909.

Chart V.—Total precipitation. The scale of shades showing the depth is given on the chart. Where the monthly amounts are too small to justify shading and over sections of the country where stations are too widely separated or the topography is too diversified to warrant reasonable accuracy in shading, the actual depths are given for a limited number of representative stations. Amounts less than 0.005 inch are indicated by the letter T, and no precipitation by 0.

Chart VI.—Percentage of clear sky between sunrise and sunset. The average cloudiness at each Weather Bureau station is determined by numerous personal observations between sunrise and sunset. The difference between the observed cloudiness and 100 is assumed to represent the percentage of clear sky, and the values thus obtained are the basis of this chart. The chart does not relate to the nighttime.

Chart VII.—Isobars and isotherms at sea level and prevailing wind directions. The pressures have been reduced to sea level and standard gravity by the method described by Prof. Frank H. Bigelow on pages 13–16 of the REWIEW for January, 1902. The pressures have also been reduced to the mean of the 24 hours by the application of a suitable correction to the mean of the 8 a. m. and 8 p. m. readings at stations taking two observations daily, and to the 8 a. m. or the 8 p. m. observation, respectively, at stations taking but a single observation. The diurnal corrections so applied will be found in the Annual Report of the Chief of the Weather Bureau, 1900–1901, volume 2, Table 27, pages 140–164.

The isotherms on the sea-level plane have been constructed by means of the data summarized in chapter 8 of volume 2 of the annual report just mentioned. The correction, t_0–t, or temperature on the sea-level plane minus the station temperature as given by Table 48 of that report, is added to the observed surface temperature to obtain the adopted sea-level temperature.

The prevailing wind directions are determined from hourly observations at the great majority of the stations; a few stations having no self-recording wind-direction apparatus determine the prevailing direction from the daily or twice-daily observations only.

Chart VIII.—Total snowfall. This is based on the reports from regular and cooperative observers and shows the depth in inches and tenths of the snowfall during the month. In general, the depth is shown by lines inclosing areas of equal snowfall, but in special cases figures are also given. Chart VIII is published only when the general snow cover is sufficiently extensive to justify its preparation.

Chart IX.—Average values of pressure, temperature, and prevailing wind directions, and storm tracks over the North Atlantic Ocean, *for the corresponding month of last year*.

[Charts XLIV–72 to XLIV–76 illustrate paper by Cleve Hallenbeck, pp. 341–342.]

TABLE I.—*Climatological data for Weather Bureau Stations, June, 1916.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.						Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F	°F.		°F	°F	°F.	°F.	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
New England.							**60.1**	**− 3.5**										**82**	**4.67**	**+ 1.6**										**6.4**		
Eastport	76	67	85	29.88	29.96	+0.03	53.5	− 0.9	72	29	61	40	16	46	24	50	48	86	3.79	+ 0.6	14	6,241	s.	40	e.	10	3	10	17	7.0	.....	.....
Greenville	1,070	6	....	28.80	29.96	.....	57.5	.....	81	27	67	38	4	48	38	.....	.....	.....	3.99	.....	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Portland, Me.	103	82	117	29.86	29.98	+ .03	58.2	− 4.4	77	29	65	44	10	51	28	54	50	78	6.32	+ 3.0	16	6,247	e.	30	nw.	22	8	9	13	6.3	.....	.....
Concord	288	70	79	29.65	29.95	− .01	60.2	− 4.2	83	27	70	42	2	51	36	.....	.....	.....	6.26	+ 2.9	19	3,638	nw.	25	nw.	22	9	9	12	5.8	.....	.....
Burlington	404	11	48	29.50	29.93	− .03	61.0	− 2.8	79	27	69	40	1	53	32	.....	.....	.....	4.32	+ 1.1	18	6,403	s.	33	s.	9	4	10	16	6.9	.....	.....
Northfield	876	12	60	29.02	29.96	.....	57.5	− 5.2	83	27	67	34	1	48	41	54	51	77	4.47	+ 1.2	19	4,971	s.	26	sw.	18	4	4	22	7.7	.....	.....
Boston	125	115	188	29.82	29.96	.00	62.6	− 3.2	84	27	70	49	10	55	24	58	54	78	5.04	+ 2.0	12	6,846	e.	28	e.	8	8	11	11	5.3	.....	.....
Nantucket	12	14	90	29.94	29.95	− .03	59.6	− 1.7	75	26	66	47	15	53	23	56	54	89	4.89	+ 2.5	16	9,404	sw.	35	ne.	8	9	11	10	5.9	.....	.....
Block Island	26	11	46	29.91	29.94	− .03	59.5	− 2.1	75	28	65	48	11	54	19	57	56	90	3.36	+ 0.5	12	10,478	w.	36	e.	8	10	8	12	5.8	.....	.....
Narragansett Pier	....	9	....	....	....	.....	60.0	− 4.2	78	29	67	45	2	53	25	.....	.....	.....	4.73	.....	19	.....	sw.	.....	.....	.....	13	7	10	.....	.....	.....
Providence	160	215	251	29.78	29.95	− .02	62.8	− 5.5	83	28	71	48	10	54	26	58	55	80	4.20	+ 1.1	16	8,410	nw.	45	nw.	22	8	9	13	6.1	.....	.....
Hartford	159	122	140	29.77	29.95	− .02	63.4	− 3.7	83	28	72	47	10	55	29	58	55	78	3.86	+ 0.8	16	4,929	nw.	38	nw.	22	7	9	14	6.7	.....	.....
New Haven	106	117	155	29.83	29.94	− .03	63.0	− 3.9	84	28	71	48	10	55	25	58	56	80	4.90	+ 1.7	16	6,181	nw.	33	e.	17	7	11	12	6.4	.....	.....
Middle Atlantic States.							**66.8**	**− 3.5**										**74**	**4.27**	**+ 0.6**										**5.8**		
Albany	97	102	115	29.83	29.93	− .04	63.0	− 4.9	81	27	71	46	1	55	31	58	53	71	2.24	− 1.5	15	5,323	s.	31	s.	3	10	9	11	6.0	.....	.....
Binghamton	871	10	69	29.02	29.94	− .03	61.4	− 4.8	82	27	70	39	1	52	35	.....	.....	.....	3.88	+ 0.3	17	3,132	e.	27	nw.	22	3	16	11	6.7	.....	.....
New York	314	414	454	29.61	29.94	− .04	64.2	− 4.3	82	28	71	51	10	57	26	58	54	75	3.94	+ 0.7	13	9,924	nw.	53	se.	16	4	13	13	6.9	.....	.....
Harrisburg	374	94	104	29.55	29.94	− .05	66.4	− 3.9	84	26	75	50	1	58	25	59	55	70	3.98	+ 0.4	14	4,760	e.	33	e.	7	11	7	12	5.9	.....	.....
Philadelphia	117	123	190	29.82	29.95	− .03	67.9	− 3.3	84	29	76	54	10	60	22	60	56	71	2.83	− 0.5	10	7,020	nw.	30	e.	7	8	11	11	6.0	.....	.....
Reading	325	81	98	29.60	29.95	.....	66.2	.....	85	27	75	49	1	58	29	59	55	71	4.51	+ 0.8	13	5,138	se.	33	e.	7	5	11	14	6.8	.....	.....
Scranton	805	111	119	29.10	29.95	− .03	63.0	− 4.2	84	27	72	44	1	54	35	58	54	74	4.68	+ 1.1	14	4,220	ne.	39	w.	18	7	12	11	6.0	.....	.....
Atlantic City	52	37	48	29.90	29.95	− .03	63.8	− 3.0	78	30	69	52	1	59	33	60	58	83	2.33	− 0.7	14	5,526	sw.	24	se.	7	7	6	17	6.9	.....	.....
Cape May	18	13	49	29.95	29.97	− .01	65.3	− 2.4	81	29	71	50	1	59	22	.....	.....	.....	3.11	+ 0.1	12	5,563	e.	30	nw.	3	10	11	9	5.2	.....	.....
Sandy Hook	22	10	57	29.92	29.94	.....	64.0	.....	82	29	70	53	10	58	21	60	58	86	3.48	.....	12	9,320	nw.	40	w.	19	9	7	14	6.1	.....	.....
Trenton	100	159	183	29.73	29.93	.....	65.8	.....	84	26	74	50	1	58	25	59	55	74	2.94	− 0.6	11	7,557	se.	35	nw.	3	5	13	12	6.6	.....	.....
Baltimore	123	100	113	29.81	29.94	− .05	69.4	− 3.6	86	28	77	53	1	62	24	62	57	68	5.33	+ 1.5	13	5,227	n.	25	e.	7	10	11	9	5.5	.....	.....
Washington	112	62	85	29.80	29.93	− .07	69.7	− 3.0	87	28	79	49	1	60	29	62	59	72	7.53	+ 3.4	13	4,196	nw.	28	se.	10	9	11	10	5.5	.....	.....
Lynchburg	681	153	188	29.19	29.92	− .09	71.0	− 2.5	93	28	82	51	1	60	29	63	60	74	6.28	+ 2.4	16	3,903	n.	37	w.	29	7	21	2	5.0	.....	.....
Norfolk	91	170	205	29.85	29.94	− .06	72.1	− 2.3	91	28	80	55	2	64	25	65	62	74	1.98	− 2.4	11	7,571	se.	75	nw.	21	13	9	8	4.8	.....	.....
Richmond	144	11	52	29.79	29.93	− .08	71.7	− 3.4	89	24	81	53	2	62	28	65	62	78	8.72	+ 5.2	17	4,809	se.	38	nw.	24	9	13	8	5.2	.....	.....
Wytheville	2,293	49	55	27.61	29.92	− .09	65.8	− 2.9	86	27	77	44	1	55	31	60	57	76	4.09	0.0	13	3,627	w.	27	sw.	6	15	11	4	3.9	.....	.....
South Atlantic States.							**75.7**	**− 0.4**										**76**	**5.69**	**+ 0.1**										**5.7**		
Asheville	2,255	70	84	27.64	29.93	− .08	67.8	− 0.9	88	29	78	48	1	57	29	61	58	75	5.15	+ 0.8	13	4,095	nw.	33	e.	27	3	21	6	5.6	.....	.....
Charlotte	773	153	161	29.11	29.93	− .08	74.1	− 1.4	93	29	84	58	1	64	27	66	63	73	5.55	+ 1.1	13	6,338	sw.	72	w.	20	5	21	4	5.1	.....	.....
Hatteras	11	12	50	29.94	29.95	− .06	73.9	− 0.5	86	28	79	61	1	68	17	69	67	80	3.89	− 0.4	10	8,745	sw.	64	nw.	3	6	18	6	5.9	.....	.....
Manteo	12	4	46	....	....	.....	72.4	.....	90	21	81	45	2	64	.....	.....	.....	.....	3.91	− 0.4	9	.....	sw.	.....	.....	.....	15	12	3	.....	.....	.....
Raleigh	376	103	110	29.54	29.93	− .08	73.6	− 1.5	92	28	83	58	2	64	26	67	63	75	7.17	+ 2.4	14	4,733	sw.	40	sw.	24	7	18	5	5.2	.....	.....
Wilmington	78	81	91	29.87	29.95	− .06	75.2	− 0.3	92	30	83	58	2	67	25	69	67	81	6.73	+ 1.1	11	5,133	sw.	34	n.	30	9	13	8	5.3	.....	.....
Charleston	48	11	92	29.90	29.96	− .05	78.0	− 0.5	92	12	84	67	7	72	23	72	69	76	9.75	+ 4.4	12	6,816	s.	38	nw.	7	7	13	10	5.9	.....	.....
Columbia, S. C.	351	41	57	29.57	29.94	− .07	78.0	− 0.2	93	30	88	62	1	68	28	68	63	70	4.15	0.0	11	5,063	w.	30	sw.	23	7	12	11	5.8	.....	.....
Augusta	180	62	77	29.74	29.93	− .08	78.2	+ 0.1	95	22	88	60	9	68	29	70	66	73	7.41	+ 2.9	10	3,944	s.	41	nw.	6	8	10	12	5.7	.....	.....
Savannah	65	150	194	29.89	29.96	− .05	78.9	+ 0.7	95	22	87	66	7	70	26	71	68	78	2.44	− 3.6	14	7,416	sw.	50	w.	7	3	18	9	6.2	.....	.....
Jacksonville	43	209	245	29.92	29.97	− .04	79.4	+ 0.4	93	7	87	66	4	72	23	72	70	79	6.45	+ 0.9	15	8,162	sw.	50	sw.	29	5	14	11	6.1	.....	.....
Florida Peninsula.							**80.2**	**− 0.2**										**75**	**4.93**	**− 1.9**										**5.2**		
Key West	22	10	64	29.95	29.97	− .02	82.0	− 0.2	89	27	87	70	13	77	15	75	72	73	1.86	− 2.4	5	5,883	se.	38	s.	17	11	13	6	4.8	.....	.....
Miami	25	71	79	29.97	30.00	.....	79.4	− 1.0	87	27	85	65	4	74	18	74	71	74	6.36	− 1.5	12	5,516	se.	36	w.	18	6	14	10	6.1	.....	.....
Sand Key	23	39	72	29.92	29.95	− .04	81.4	.....	89	26	84	72	2	79	11	75	73	76	0.46	.....	5	7,377	se.	48	s.	17	14	11	5	4.1	.....	.....
Tampa	35	79	96	29.95	29.98	− .03	79.3	+ 0.6	92	30	87	66	3	72	19	72	70	76	6.58	− 1.8	12	4,115	se.	34	nw.	8	5	17	8	6.0	.....	.....
Titusville	44	6	....	....	....	.....	....	.....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	.....	.....	.....
East Gulf States.							**78.0**	**− 0.1**										**74**	**4.03**	**− 0.5**										**5.2**		
Atlanta	1,174	190	216	28.74	29.95	− .06	75.2	− 0.4	91	30	84	59	9	66	23	66	61	67	3.28	− 0.6	12	6,264	w.	36	w.	6	8	10	12	5.7	.....	.....
Macon	370	78	87	29.54	29.93	− .07	78.2	+ 1.1	95	22	88	58	9	68	30	69	65	69	3.62	0.0	10	3,852	s.	29	s.	6	8	14	8	5.7	.....	.....
Thomasville	273	49	58	29.67	29.96	− .04	78.6	− 0.9	95	22	88	64	2	69	27	70	67	76	3.55	− 1.2	15	3,138	sw.	20	nw.	12	3	9	18	7.4	.....	.....
Pensacola	56	140	182	29.90	29.96	− .03	79.1	− 0.9	92	23	85	65	13	73	26	72	70	77	4.70	− 0.2	13	8,171	sw.	66	s.	13	8	12	10	5.9	.....	.....
Anniston	741	9	57	29.18	29.96	− .04	75.6	+ 0.6	94	30	87	55	8	64	31	.....	.....	.....	1.71	− 2.2	12	3,151	nw.	28	w.	6	13	16	1	3.9	.....	.....
Birmingham	700	11	48	29.21	29.96	− .03	76.2	− 2.0	94	22	86	58	8	66	29	67	64	72	2.02	− 1.9	9	4,009	s.	37	s.	6	4	17	9	5.8	.....	.....
Mobile	57	125	161	29.89	29.95	− .04	79.6	+ 0.5	94	26	87	66	9	72	23	72	70	78	5.42	− 0.5	13	6,036	sw.	39	n.	30	7	19	4	5.1	.....	.....
Montgomery	223	100	112	29.70	29.95	− .05	79.2	+ 0.1	94	22	89	58	9	69	30	70	65	68	2.81	− 1.4	10	4,197	w.	41	nw.	12	7	17	6	5.3	.....	.....
Corinth	469	6	....	....	....	.....	75.6	.....	96	30	...	54	17	...	30	.....	.....	.....	4.02	.....	8	.....	.....	.....	.....	.....	2	27	1	.....	.....	.....
Jackson	304	5	....	....	....	.....	78.5	.....	96	22	89	55	9	68	33	.....	.....	.....	4.47	.....	8	.....	s.	.....	.....	.....	7	20	3	.....	.....	.....
Meridian	375	85	93	29.54	29.93	− .05	77.0	− 0.3	93	22	87	57	9	67	30	71	68	77	2.79	− 1.8	15	3,388	sw.	32	w.	27	11	11	8	4.9	.....	.....
Vicksburg	247	65	74	29.67	29.94	− .03	77.7	− 0.8	91	22	86	62	8	69	23	71	68	78	4.77	+ 0.3	13	4,246	sw.	30	w.	6	10	15	5	3.0	.....	.....
New Orleans	51	76	84	29.89	29.94	− .04	81.6	+ 2.0	92	23	89	68	15	74	19	74	72	77	9.70	+ 3.5	15	3,900	sw.	28	se.	23	7	23	0	4.6	.....	.....
West Gulf States.							**79.4**	**+ 0.4**										**73**	**2.48**	**− 1.4**										**4.7**		
Shreveport	249	77	93	29.64	29.90	− .06	79.4	− 0.2	95	21	89	62	8	70	24	71	68	73	3.08	− 0.5	13	4,774	s.	35	s.	5	14	7	9	4.9	.....	.....
Bentonville	1,303	11	44	28.54	29.88	− .06	71.8	− 2.3	90	29	82	53	8	62	29	.....	.....	.....	4.73	+ 0.2	14	2,804	sw.	21	nw.	11	7	16	7	5.3	.....	.....
Fort Smith	457	79	94	29.40	29.87	− .07	76.1	− 0.7	93	20	86	56	8	67	26	70	67	77	2.72	− 1.3	12	5,725	e.	44	w.	6	7	11	12	6.0	.....	.....
Little Rock	357	139	147	29.53	29.89	− .07	76.6	− 0.6	93	22	85	55	8	68	28	68	65	71	3.00	− 1.1	11	6,274	s.	52	s.	5	9	12	9	5.4	.....	.....
Brownsville	57	3	40	....	....	.....	84.4	.....	99	16	94	71	17	75	26	.....	.....	.....	0.17	.....	2	.....	se.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Corpus Christi	20	69	77	29.86	29.88	− .03	81.9	+ 1.3	95	15	86	70	29	77	19	76	74	82	1.98	− 0.8	3	12,749	se.	46	se.	5	10	14	6	5.0	.....	.....
Dallas	512	109	117	29.34	29.87	.....	79.8	.....	96	2	90	60	8	70	28	.....	.....	.....	4.08	.....	9	7,768	se.	55	ne.	26	12	14	4	4.6	.....	.....
Forth Worth	670	106	114	29.14	29.84	− .08	80.2	+ 0.1	97	26	90	58	8	70	27	69	64	62	3.30	+ 0.3	4	8,674	se.	40	nw.	25	5	19	6	5.2	.....	.....
Galveston	54	106	114	29.87	29.93	− .02	81.0	+ 0.1	89	17	85	64	7	77	17	75	73	80	3.15	− 1.6	4	8,946	s.	40	nw.	15	23	5	2	3.0	.....	.....
Houston	138	111	121	29.76	29.90	.....	81.6	+ 0.6	97	26	91	64	8	72	24	.....	.....	.....	1.80	.....	7	5,996	se.	40	n.	7	8	14	8	5.5	.....	.....
Palestine	510	64	72	29.36	29.88	− .06	78.8	+ 0.4	92	21	88	59	9	70	29	71	68	75	1.87	− 2.1	6	5,579	s.	30	sw.	5	15	10	5	4.4	.....	.....
San Antonio	701	109	132	29.13	29.84	− .06	84.0	+ 3.6	100	4	96	63	15	72	28	71	66	63	0.49	− 2.6	5	6,956	sw.	40	se.	27	23	7	0	2.9	.....	.....
Taylor	582	55	63	29.29	29.90	− .02	82.0	+ 2.0	98	24	92	63	8	72	26	.....	.....	.....	0.48	− 3.0	3	8,144	s.	39	ne.	27	14	15	1	3.8	.....	.....

TABLE I.—*Climatological data for Weather Bureau Stations, June, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	°F.	°F.	%	*In.*	*In.*		*Miles.*								*0–10*	*In.*	*In.*
							69.3	— 3.8												71	6.64	+ 0.4										5.8		
Chattanooga	762	189	213	29.15	29.94	−0.06	73.4	— 2.0	92	30	83	56	17	64	24	65	61	70	5.08	+ 0.8	16	5,144	w.	46	sw.	6	6	15	9	5.7	.....	.....
Knoxville	996	93	100	28.89	29.92	— .08	72.8	— 0.6	93	29	83	56	4	63	25	65	61	71	5.29	+ 1.1	12	3,349	sw.	28	w.	16	6	14	10	5.8	.....	.....
Memphis	399	76	97	29.51	29.93	— .04	75.9	— 1.8	92	29	84	61	7	68	22	68	64	70	3.19	— 1.2	12	5,870	sw.	50	sw.	6	10	9	11	5.8	.....	.....
Nashville	546	168	191	29.35	29.93	— .06	72.9	— 3.4	93	30	82	55	4	63	26	65	61	69	4.62	+ 0.2	13	5,835	w.	45	sw.	6	12	10	8	5.1	.....	.....
Lexington	989	193	230	28.86	29.90	— .10	69.0	— 4.2	90	30	78	54	10	60	30	.....	.....	.....	5.33	+ 1.3	12	8,602	sw.	46	sw.	2	9	13	8	5.2	.....	.....
Louisville	525	219	255	29.34	29.92	— .06	70.6	— 4.4	92	30	80	54	4	62	26	63	58	67	6.05	+ 1.8	14	8,144	sw.	54	w.	8	8	11	11	6.0	.....	.....
Evansville	431	139	175	29.44	29.90	— .07	71.9	— 3.4	96	30	81	58	8	63	26	65	61	70	4.58	+ 0.4	12	7,403	sw.	45	sw.	8	11	12	7	5.0	.....	.....
Indianapolis	822	194	230	29.02	29.89	— .08	67.2	— 5.2	88	29	76	51	11	58	26	60	56	70	5.92	+ 1.6	14	7,899	sw.	39	n.	14	4	13	13	6.3	.....	.....
Terre Haute	575	96	129	29.26	29.86	.....	68.6	.....	94	30	78	54	4	59	28	61	57	71	5.32	.....	15	6,608	sw.	35	w.	7	0	20	10	6.9	.....	.....
Cincinnati	628	11	51	29.23	29.90	— .09	67.3	— 4.4	92	30	77	50	22	58	28	61	57	70	4.32	+ 0.3	12	4,761	sw.	29	sw.	8	6	12	12	6.0	.....	.....
Columbus	824	173	222	29.04	29.90	— .09	65.9	— 5.1	86	29	75	49	22	57	25	60	56	73	3.49	0.0	13	6,995	sw.	40	w.	16	17	9	4	3.9	.....	.....
Dayton	899	181	216	28.93	29.87	.....	66.2	— 6.0	88	29	75	51	22	57	30	60	57	75	5.06	+ 1.1	12	6,739	sw.	44	nw.	2	7	14	9	5.7	.....	.....
Pittsburgh	842	353	410	29.03	29.92	— .07	65.3	— 5.8	83	26	74	48	1	57	29	59	55	70	3.82	— 0.1	13	7,358	nw.	44	nw.	3	1	16	13	7.1	.....	.....
Elkins	1,940	41	50	27.92	29.93	— .07	63.7	— 2.9	87	24	76	40	1	51	40	57	55	80	4.86	— 0.2	14	2,316	nw.	20	w.	3	3	11	16	7.3	.....	.....
Parkersburg	638	77	84	29.28	29.93	— .07	67.6	— 3.9	86	29	78	48	4	58	29	61	57	74	3.30	— 1.4	15	3,354	n.	24	sw.	8	10	10	10	5.4	.....	.....
Lower Lake Region.							62.6	— 4.4												75	4.07	+ 0.5										5.9		
Buffalo	767	247	280	29.09	29.91	— .06	61.4	— 3.7	81	24	68	46	1	55	26	56	53	78	4.04	+ 0.9	16	9,149	sw.	58	sw.	9	4	10	16	6.9	.....	.....
Canton	448	10	61	29.44	29.91	.....	61.2	— 4.6	83	2	70	40	1	52	37	.....	.....	.....	2.84	— 0.6	15	6,424	w.	58	sw.	18	4	15	11	6.2	.....	.....
Oswego	335	76	91	29.56	29.92	— .05	59.1	— 4.7	80	2	66	43	1	52	31	55	52	80	5.85	+ 2.4	15	6,274	w.	34	se.	7	7	10	13	6.1	.....	.....
Rochester	523	97	113	29.37	29.93	— .04	62.6	— 3.5	84	24	71	45	1	54	28	57	53	72	5.72	+ 2.6	16	5,332	se.	29	w.	18	7	8	15	6.6	.....	.....
Syracuse	597	97	113	29.31	29.95	— .02	61.3	— 5.6	81	27	69	47	1	54	28	57	54	78	5.12	+ 1.2	17	6,806	nw.	31	nw.	22	6	13	11	6.3	.....	.....
Erie	714	130	166	29.14	29.91	— .07	63.2	— 3.8	86	24	71	43	1	56	28	58	54	75	3.35	— 0.4	13	9,219	se.	52	sw.	24	5	23	2	5.1	.....	.....
Cleveland	762	190	201	29.09	29.90	— .08	62.8	— 5.1	82	24	70	44	1	56	30	58	54	72	1.98	— 1.7	15	7,805	s.	39	w.	16	6	13	11	6.0	.....	.....
Sandusky	629	62	103	29.21	29.89	— .09	64.8	— 4.0	85	26	73	46	1	57	27	59	55	73	4.36	+ 0.5	14	7,440	sw.	38	sw.	2	3	21	6	5.6	.....	.....
Toledo	628	208	243	29.22	29.89	— .08	64.6	— 4.8	84	26	73	48	1	56	25	58	54	72	4.42	+ 1.0	16	9,480	sw.	45	sw.	2	13	11	6	4.8	.....	.....
Fort Wayne	856	113	124	28.97	29.89	.....	64.2	— 4.3	84	23	73	48	11	55	27	59	56	77	5.78	.....	17	6,374	sw.	37	sw.	2	5	16	9	6.1	.....	.....
Detroit	730	218	245	29.11	29.89	— .08	63.4	— 4.4	81	13	71	48	20	56	22	57	53	71	3.00	— 0.9	15	7,614	s.	37	w.	2	8	15	7	4.8	.....	.....
Upper Lake Region.							58.2	— 4.3												77	5.45	+ 2.1										6.2		
Alpena	609	13	92	29.23	29.89	— .07	57.0	— 3.3	78	24	65	40	20	49	27	53	50	80	3.67	+ 0.1	14	8,094	se.	48	e.	7	5	13	12	6.1	.....	.....
Escanaba	612	54	60	29.21	29.87	— .07	56.3	— 4.3	78	26	64	38	20	49	30	52	49	77	6.01	+ 2.4	18	6,536	s.	39	e.	7	9	7	14	6.1	.....	.....
Grand Haven	632	54	92	29.18	29.85	— .11	59.0	— 5.7	82	29	67	44	10	51	25	54	51	79	6.07	+ 3.6	14	7,118	w.	44	s.	2	15	7	8	4.3	.....	.....
Grand Rapids	707	70	87	29.11	29.87	— .10	62.5	— 5.6	81	13	72	46	20	53	27	57	52	71	6.56	+ 4.0	14	4,410	w.	22	w.	15	5	16	9	5.8	.....	.....
Houghton	684	62	72	29.13	29.85	— .09	54.9	— 4.5	75	23	63	40	3	46	34	.....	.....	.....	5.34	+ 1.8	16	6,982	e.	40	ne.	7	4	9	17	7.3	.....	.....
Lansing	878	11	62	28.94	29.87	.....	61.4	— 6.0	81	13	71	41	20	51	30	57	53	76	5.39	+ 2.0	18	3,818	sw.	21	e.	6	4	16	10	6.3	.....	.....
Ludington	637	60	66	29.17	29.86	.....	57.1	.....	77	30	64	42	11	50	23	53	50	79	3.94	.....	13	6,234	s.	33	sw.	2	12	12	6	4.7	.....	.....
Marquette	734	77	111	29.10	29.90	— .04	52.9	— 5.6	75	26	61	37	21	45	29	50	47	81	7.26	+ 3.8	18	5,549	nw.	43	e.	7	1	9	20	8.0	.....	.....
Port Huron	638	70	120	29.20	29.89	— .08	60.0	— 3.8	81	2	69	42	1	52	27	55	52	77	2.41	— 0.8	16	6,979	ne.	36	se.	7	5	22	3	5.4	.....	.....
Saginaw	641	48	82	29.19	29.88	.....	62.2	.....	82	13	72	42	20	53	29	57	53	72	2.68	0.0	11	6,297	s.	38	se.	8	3	12	15	7.2	.....	.....
Sault Ste. Marie	614	11	61	29.21	29.90	— .06	55.2	— 2.4	78	30	64	37	18	46	31	51	48	79	4.15	+ 1.4	14	6,068	w.	38	se.	7	8	5	17	6.9	.....	.....
Chicago	823	140	310	29.00	29.88	— .08	63.5	— 2.8	88	29	70	50	7	57	24	57	54	75	7.25	+ 3.6	18	8,262	w.	44	ne.	6	10	10	10	5.5	.....	.....
Green Bay	617	109	144	29.18	29.84	— .11	60.4	— 4.7	80	23	68	45	20	53	25	56	52	76	6.73	+ 3.2	15	7,612	ne.	44	ne.	7	1	18	11	7.1	.....	.....
Milwaukee	681	119	133	29.12	29.85	— .10	60.0	— 3.5	81	23	67	47	7	53	26	55	52	77	6.60	+ 2.9	17	6,592	w.	56	se.	2	8	15	7	5.4	.....	.....
Duluth	1,133	11	47	28.68	29.89	— .03	53.8	— 3.9	76	12	63	36	19	45	31	50	46	77	5.81	+ 1.3	12	8,024	ne.	42	sw.	14	9	4	17	6.3	.....	.....
North Dakota.							58.9	— 4.8												71	3.66	0.0										5.8		
Moorhead	940	8	57	28.88	29.89	— .01	60.3	— 4.0	84	30	71	40	2	50	30	54	52	76	4.28	+ 0.2	14	5,811	nw.	32	e.	22	10	11	9	5.1	.....	.....
Bismarck	1,674	8	57	28.14	29.91	+ .04	59.2	— 5.0	82	30	70	38	2	48	37	53	47	68	1.50	— 2.0	11	7,482	nw.	40	e.	22	8	12	10	5.9	.....	.....
Devils Lake	1,482	11	44	28.30	29.86	— .02	57.5	— 5.1	78	30	68	37	4	48	32	52	47	70	4.14	+ 0.6	10	7,557	w.	46	e.	22	7	8	15	6.2	.....	.....
Grand Forks	835	12	89	.....	.....	.....	58.6	.....	81	30	70	35	2	47	35	.....	.....	.....	3.40	.....	11	.....	nw.	70	se.	22	10	13	7	.....	.....	.....
Williston	1,872	41	48	27.90	29.86	.00	58.6	— 4.9	80	27	69	37	2	48	34	52	47	69	4.73	+ 1.2	14	7,736	e.	40	nw.	6	6	13	11	6.0	.....	.....
Upper Mississippi Valley.							66.2	— 4.7												72	4.20	— 0.2										5.8		
Minneapolis	918	10	208	28.88	29.85	.....	62.9	.....	85	30	71	48	9	55	25	.....	.....	.....	4.54	+ 0.5	14	8,390	nw.	36	n.	25	2	13	15	7.3	.....	.....
St. Paul	837	201	236	28.94	29.84	— .08	62.7	— 4.7	82	25	71	48	9	54	26	.....	.....	.....	3.79	— 0.6	15	8,836	nw.	56	se.	22	8	17	5	5.0	.....	.....
La Crosse	714	11	48	29.08	29.84	— .09	63.2	— 5.0	84	29	72	48	5	54	29	.....	.....	.....	4.30	— 0.1	13	3,434	nw.	19	nw.	7	2	18	10	6.6	.....	.....
Madison	974	70	78	28.83	29.86	— .08	61.8	— 5.5	86	29	70	45	21	54	28	56	53	75	4.52	+ 0.4	13	6,114	w.	30	nw.	7	2	13	15	7.4	.....	.....
Wausau	1,247	4	.....	28.53	29.85	.....	59.0	.....	79	12	68	42	19	50	32	.....	.....	.....	5.74	.....	17	.....	nw.	.....	.....	.....	.....	.....	4	10	16	6.9	.....	.....
Charles City	1,015	10	49	28.80	29.86	— .05	62.6	— 6.2	92	30	73	44	5	52	32	58	55	75	4.65	— 0.4	13	4,678	nw.	27	se.	22	6	19	5	5.1	.....	.....
Davenport	606	71	79	29.20	29.86	— .08	65.8	— 5.1	92	30	75	49	21	57	28	59	55	70	3.19	— 0.9	8	5,596	nw.	32	nw.	15	7	13	10	6.0	.....	.....
Des Moines	861	84	97	28.97	29.86	— .06	66.5	— 3.9	92	30	76	46	3	57	31	59	54	67	2.24	— 2.7	13	5,123	nw.	27	sw.	29	7	12	11	5.8	.....	.....
Dubuque	698	81	96	29.14	29.88	— .05	64.0	— 5.6	90	29	73	49	21	55	26	58	54	71	4.61	+ 0.1	14	4,617	nw.	29	nw.	1	5	15	10	6.0	.....	.....
Keokuk	614	64	78	29.21	29.87	— .07	67.4	— 5.1	93	30	76	51	7	59	24	62	59	75	3.74	— 0.6	13	5,345	w.	44	se.	23	12	12	6	4.5	.....	.....
Cairo	356	87	93	29.50	29.87	— .10	73.1	— 2.1	93	30	81	57	8	65	25	67	64	76	8.00	+ 3.7	13	5,316	n.	50	sw.	18	7	14	9	5.9	.....	.....
Peoria	609	11	45	29.22	29.87	— .08	65.8	— 5.1	92	30	75	49	5	56	29	60	57	76	2.55	— 1.8	12	4,758	w.	25	ne.	20	14	9	7	4.9	.....	.....
Springfield, Ill.	644	10	91	29.19	29.86	— .09	68.3	— 4.0	96	30	78	53	9	59	29	61	57	70	3.14	— 1.2	9	6,063	w.	30	w.	7	10	9	11	5.8	.....	.....
Hannibal	534	74	109	29.30	29.86	— .09	68.0	— 5.3	94	30	77	51	7	59	26	.....	.....	.....	5.56	+ 2.0	13	6,033	sw.	35	nw.	7	12	10	8	4.8	.....	.....
St. Louis	567	265	303	29.27	29.87	— .08	71.5	— 3.6	95	30	80	55	7	63	26	63	59	67	3.97	— 0.5	11	8,660	nw.	43	se.	22	12	13	5	4.9	.....	.....
Missouri Valley.							67.1	— 3.9												70	4.20	— 0.2										4.7		
Columbia, Mo.	781	11	84	29.05	29.86	— .09	69.0	— 5.5	93	30	78	52	10	60	26	.....	.....	.....	3.64	— 0.7	11	5,368	w.	36	w.	2	9	13	8	5.2	.....	.....
Kansas City	963	161	181	28.86	29.87	— .05	70.5	— 2.5	91	30	79	52	6	62	22	63	58	68	5.51	+ 0.8	11	8,103	n.	45	n.	6	16	10	4	4.0	.....	.....
St. Joseph	967	11	49	28.86	29.87	.....	69.6	.....	92	30	80	51	8	60	29	62	57	70	3.34	.....	10	5,714	nw.	35	nw.	8	12	15	3	4.1	.....	.....
Springfield, Mo.	1,324	98	104	28.51	29.89	— .06	70.0	— 2.3	88	30	78	53	7	62	24	64	61	75	5.00	— 0.2	11	6,868	se.	35	w.	8	13	12	5	4.1	.....	.....
Iola	984	11	50	28.86	29.84	— .09	71.4	— 2.0	91	1	81	50	9	62	29	.....	.....	.....	8.58	+ 3.8	10	4,704	s.	29	n.	26	12	16	2	3.8	.....	.....
Topeka	983	85	101	.....	.....	.....	70.2	— 3.3	90	29	80	51	9	61	28	.....	.....	.....	5.97	+ 1.2	12	6,659	nw.	34	e.	20	9	16	5	5.0	.....	.....
Drexel	1,299	10	53	28.52	29.89	.....	65.4	.....	91	30	76	44	7	55	32	60	57	75	3.13	.....	12	6,854	nw.	40	e.	21	12	11	7	4.8	.....	.....
Lincoln	1,189	11	84	28.63	29.87	— .03	67.8	— 3.8	94	30	79	46	7	57	36	60	55	68	3.11	— 1.2	10	7,117	n.	42	nw.	22	12	12	6	4.6	.....	.....
Omaha	1,105	115	121	28.72	29.88	— .03	68.0	— 3.6	92	30	77	50	7	59	30	61	57	69	2.58	— 2.5	10	5,753	nw.	33	nw.	15	10	14	6	4.9	.....	.....
Valentine	2,598	47	54	27.23	29.91	+ .05	62.2	— 4.9	92	29	74	40	8	51	34	55	50	69	3.15	— 0.7	14	7,364	nw.	46	n.	25	8	14	8	5.5	.....	.....
Sioux City	1,135	94	164	28.69	29.88	— .02	65.2	— 4.2	92	30	76	47	19	55	34	59	55	70	2.32	— 1.6	13	8,857	nw.	60	nw.	22	13	14	3	3.9	.....	.....
Huron	1,306	59	74	28.52	29.91	— .03	62.2	— 4.4	88	28	73	45	7	52	29	57	54	75	3.51	— 0.3	13	8,023	nw.	46	s.	27	8	13	9	5.5	.....	.....
Pierre	1,572	70	75	28.25	29.89	+ .02	63.5	— 5.4	95	28	74	45	7	53	32	56	60	65	2.33	— 0.8	15	7,343	nw.	42	w.	23	11	12	7	5.1	.....	.....
Yankton	1,233	49	57	28.58	29.88	+ .01	64.8	— 4.6	94	30	75	48	7	55	29	.....	.....	.....	4.68	+ 0.4	11	5,890	nw.	31	nw.	7	11	13	6	5.0	.....	.....

TABLE I.—*Climatological data for Weather Bureau Stations, June, 1916*—Continued.

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.														Mean wet thermometer.	Mean temperature of the dew point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.								Total.	Departure from normal.	Days with 0.01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*	°*F.*	%	*In.*	*In.*		*Miles.*						*0–10*	*In.*	*In.*
Northern Slope.							**58.8**	**− 3.3**											**61**	**2.64**	**+ 0.4**								**4.8**		
Billings	3,140	5					61.4		92	17	76	36	7	47	46					2.50				sw.				11	15	4			
Havre	2,505	11	44	27.28	29.89	+0.04	59.3	− 3.1	84	16	69	40	6	49	29	53	48	72		4.03	+ 1.2	16	6,279	nw.	30	w.	2	8	12	10	5.8		
Helena	4,110	87	114	25.78	29.93	+ .05	57.2	− 3.4	89	17	68	35	21	46	36	47	40	59		3.60	+ 1.5	13	6,642	sw.	35	sw.	5	12	11	7	4.7		
Kalispell	2,962	11	34	26.90	29.92	+ .03	55.3	− 3.5	88	18	67	33	2	43	40	48	42	68		3.91	+ 2.2	14	3,126	w.	36	sw.	18	6	17	7	5.8	T.	
Miles City	3,259	50	58	27.39	29.91	+ .06	63.4	− 2.6	90	29	76	38	2	51	36	55	49	64		3.96	+ 1.2	17	5,083	nw.	34	w.	5	7	20	3	4.7		
Rapid City	3,259	50	58	26.56	29.93	+ .08	60.1	− 3.7	92	28	70	42	7	51	32	52	46	60		2.30	− 1.3	16	6,265	n.	39	nw.	5	8	13	9	5.8		
Cheyenne	6,088	84	101	23.99	29.84	.00	58.4	− 3.1	88	28	72	30	7	45	41	47	38	54		0.37	− 1.2	5	8,081	nw.	54	w.	22	15	13	2	4.1		
Lander	5,372	60	68	24.61	29.85	.00	60.2	− 1.1	94	27	76	31	2	44	44	46	31	42		0.19	− 0.9	3	4,299	w.	32	w.	9	19	10	1	3.4		
Sheridan	3,790	10	47	26.06	29.91	.....	59.0	.....	90	29	72	35	2	46	39	51	44	62		2.23	.....	15	4,348	nw.	36	sw.	9	14	8	8	4.7		
Yellowstone Park	6,200	11	48	23.88	29.92	+ .06	50.5	− 5.5	80	17	64	29	12	37	40	41	32	56		2.36	+ 0.7	13	4,737	s.	34	s.	29	12	11	7	4.8	3.7	
North Platte	2,821	11	51	27.03	29.92	+ .06	64.6	− 3.8	95	28	77	38	7	52	38	57	52	71		3.09	− 0.2	13	5,214	se.	33	n.	25	14	8	8	4.5		
Middle Slope.							**70.4**	**− 1.4**											**62**	**4.27**	**+ 1.1**								**4.3**		
Denver	5,292	106	113	24.69	29.84	.00	66.1	− 0.3	96	29	80	42	7	52	39	51	38	43		0.08	− 1.4	2	5,570	se.	39	n.	19	16	14	0	3.6		
Pueblo	4,685	80	86	25.22	29.80	− .03	69.6	+ 0.6	99	29	85	43	5	54	43	53	41	46		1.22	− 0.2	5	5,157	se.	37	e.	10	17	11	2	3.1		
Concordia	1,392	50	58	28.44	29.88	− .02	69.2	− 3.5	90	29	80	48	8	59	30	62	57	69		4.66	− 0.3	9	5,673	nw.	31	s.	25	7	16	7	5.3		
Dodge	2,509	11	51	27.31	29.85	− .02	70.6	− 2.5	94	1	82	50	8	59	42	62	58	69		5.16	+ 1.8	13	7,959	se.	38	ne.	11	13	13	4	4.2		
Wichita	1,358	139	158	28.44	29.84	− .07	72.4	− 1.9	94	1	82	55	8	63	26	65	61	73		8.32	+ 3.6	10	9,033	s.	52	ne.	5	14	13	3	4.4		
Altus	1,410	5	.....	.....	.....	.....	79.0	.....	105	1	92	54	8	66	40	.....	.....	.....		3.74	.....	10	.....	se.	.....	.....	.....	14	5	11	.....	.....	.....
Muskogee	652	4	.....	.....	.....	.....	75.0	.....	93	27	85	55	8	65	28	.....	.....	.....		3.17	.....	14	.....	s.	.....	.....	.....	17	3	10	.....	.....	.....
Oklahoma	1,214	10	47	28.61	29.85	− .06	74.6	− 1.1	96	1	84	55	6	65	32	67	64	73		6.16	+ 3.1	15	9,912	s.	61	n.	14	10	17	3	5.1	.....	.....
Southern Slope.							**80.0**	**+ 2.9**											**49**	**1.19**	**− 1.5**								**3.8**		
Abilene	1,738	10	52	28.04	29.79	− .09	81.0	+ 2.8	102	26	93	53	8	69	36	67	60	54		2.05	− 1.1	7	9,243	se.	47	n.	26	21	8	1	3.1	.....	.....
Amarillo	3,676	10	49	26.18	29.82	− .03	74.6	+ 2.6	100	21	89	50	7	60	37	62	56	61		2.18	− 0.8	7	8,988	s.	35	n.	4	17	11	2	3.2	.....	.....
Del Rio	944	64	71	28.84	29.79	− .06	86.4	+ 4.3	109	6	98	66	15	75	36	.....	.....	.....		0.08	− 2.4	1	9,356	se.	42	e.	30	20	10	0	2.9	.....	.....
Roswell	3,566	75	85	26.24	29.75	− .05	78.2	+ 1.9	100	25	95	53	5	62	41	56	38	31		0.44	− 1.6	1	6,281	s.	39	sw.	4	24	6	0	1.9	.....	.....
Southern Plateau.							**74.6**	**0.0**											**25**	**0.08**	**− 0.3**								**1.0**		
El Paso	3,762	110	133	26.06	29.69	− .06	83.8	+ 4.2	102	29	97	62	8	70	33	56	28	17		0.00	− 0.6	0	8,501	nw.	52	w.	4	28	2	0	1.2	.....	.....
Santa Fe	7,013	57	66	23.25	29.73	− .08	66.2	0.0	87	30	80	44	1	53	32	46	27	26		0.38	− 0.7	1	5,787	sw.	30	n.	4	20	8	2	2.4	.....	.....
Flagstaff	6,908	8	57	23.36	29.79	+ .01	58.9	− 0.4	86	16	78	32	19	40	49	.....	.....	.....		0.00	.....	0	.....	w.	38	sw.	20	25	5	0	.....	.....	.....
Phoenix	1,108	76	81	28.60	29.72	− .02	83.9	− 0.5	111	15	101	57	1	67	44	58	37	22		0.00	− 0.1	0	3,981	e.	22	w.	3	30	0	0	0.3	.....	.....
Yuma	141	9	54	29.57	29.71	− .03	85.4	+ 0.7	116	15	104	56	4	66	48	63	48	35		0.00	0.0	0	3,712	w.	27	w.	3	30	0	0	0.1	.....	.....
Independence	3,910	11	42	25.87	29.78	.00	69.5	− 3.9	97	16	88	40	3	51	44	.....	.....	.....		0.00	− 0.1	0	4,654	se.	27	w.	27	29	1	0	.....	.....	.....
Middle Plateau.							**64.1**	**− 1.0**											**30**	**0.11**	**− 0.4**								**2.0**		
Reno	4,532	74	81	25.44	29.87	+ .01	61.8	+ 0.8	96	16	78	34	2	46	44	46	31	40		0.11	− 0.1	1	5,450	w.	36	w.	19	22	7	1	2.3	.....	.....
Tonopah	6,090	12	20	24.03	29.83	.....	64.6	.....	87	16	77	34	21	52	29	45	25	25		0.00	− 0.4	0	6,420	w.	36	nw.	20	23	7	0	2.1	.....	.....
Winnemucca	4,344	18	56	25.58	29.91	+ .03	61.6	− 1.7	98	16	79	29	22	44	44	44	28	36		0.00	− 0.6	0	4,744	ne.	29	nw.	19	24	5	1	1.7	.....	.....
Modena	5,479	10	43	24.56	29.80	− .02	63.0	− 0.2	91	16	82	32	2	44	47	43	20	25		0.01	− 0.4	1	8,734	w.	44	s.	20	25	5	0	1.7	.....	.....
Salt Lake City	4,360	147	189	25.56	29.85	.00	65.9	− 2.4	96	17	78	40	22	54	35	49	32	32		0.66	− 0.1	3	6,058	nw.	35	n.	20	21	6	3	2.6	.....	.....
Durango	6,546	10	.....	23.65	29.81	− .01	60.8	− 1.9	87	30	81	33	1	40	45	.....	.....	.....		T.	− 0.8	0	.....	nw.	.....	.....	.....	28	2	0	.....	.....	.....
Grand Junction	4,602	82	96	25.29	29.79	− .04	71.7	− 0.9	94	30	86	43	2	57	37	49	25	20		T.	− 0.4	0	6,082	nw.	34	s.	21	25	5	0	1.7	.....	.....
Northern Plateau.							**61.2**	**− 3.8**											**51**	**1.63**	**+ 0.5**								**4.7**		
Baker	3,471	48	53	26.44	30.00	+ .05	55.7	− 2.9	93	17	69	31	10	42	40	46	38	58		1.43	+ 0.2	8	4,134	se.	22	n.	4	13	8	9	4.5	.....	.....
Boise	2,739	78	86	27.12	29.96	+ .05	61.8	− 4.2	98	16	76	36	21	48	43	49	37	48		1.68	+ 0.8	7	3,821	nw.	26	w.	20	15	8	7	4.1	.....	.....
Lewiston	757	40	48	29.16	29.96	+ .02	64.4	− 4.7	104	17	78	43	2	51	46	.....	.....	.....		1.91	+ 0.9	11	2,419	ne.	24	nw.	9	9	11	10	5.2	.....	.....
Pocatello	4,477	46	54	25.43	29.89	+ .02	60.0	− 4.2	92	17	75	34	11	45	41	45	31	39		0.32	− 0.7	4	6,308	sw.	38	sw.	5	18	10	2	3.5	T.	.....
Spokane	1,929	101	110	27.93	29.95	+ .01	60.6	− 2.8	96	17	73	38	11	49	36	50	41	57		2.70	+ 1.1	13	4,365	sw.	36	sw.	27	7	10	13	6.2	.....	.....
Walla Walla	991	57	65	28.88	29.94	− .02	64.4	− 3.8	99	16	76	41	22	52	35	53	42	51		1.77	+ 0.6	8	3,419	s.	24	sw.	4	12	8	10	4.8	.....	.....
North Pacific Coast Region.							**57.8**	**− 0.4**											**74**	**1.56**	**− 0.5**								**5.6**		
North Head	211	11	56	29.84	30.06	+ .07	53.2	− 1.8	68	12	56	46	9	50	15	50	49	88		1.27	− 0.5	12	12,007	nw.	52	se.	30	5	11	14	6.4	.....	.....
Seattle	125	215	250	29.94	30.06	+ .06	58.8	− 1.3	82	16	67	44	5	51	27	52	47	70		1.82	+ 0.1	9	5,104	n.	30	sw.	27	9	6	15	6.4	.....	.....
Tacoma	213	113	120	29.84	30.06	+ .03	58.8	− 0.6	81	16	68	43	10	50	28	52	48	72		1.66	− 0.5	12	4,006	n.	20	sw.	4	8	8	14	6.0	.....	.....
Tatoosh Island	109	7	57	29.97	30.06	+ .04	52.8	− 0.2	71	12	57	46	11	48	23	50	48	89		1.88	− 2.3	10	6,434	sw.	30	e.	30	9	9	12	5.4	.....	.....
Medford	1,425	4	.....	.....	.....	.....	63.8	.....	101	16	80	35	10	47	51	.....	.....	.....		0.73	.....	9	.....	nw.	.....	.....	.....	13	3	14	.....	.....	.....
North Yakima	1,076	4	.....	.....	.....	.....	64.4	.....	96	17	78	41	28	51	40	.....	.....	.....		0.63	.....	6	.....	.....	.....	.....	.....	13	6	11	.....	.....	.....
Portland, Oreg	153	68	106	29.87	30.03	− .01	62.0	+ 0.7	92	16	72	41	10	52	32	53	47	63		1.83	0.0	11	4,284	nw.	31	sw.	17	10	8	12	5.6	.....	.....
Roseburg	510	9	57	29.49	30.04	+ .01	61.4	+ 0.5	98	16	75	37	10	48	45	52	45	63		0.91	− 0.2	8	2,645	nw.	18	n.	5	14	12	4	3.8	.....	.....
Middle Pacific Coast Region.							**60.7**	**− 1.9**											**61**	**0.54**	**0.0**								**3.1**		
Eureka	62	73	89	29.98	30.05	.00	52.8	− 1.8	71	30	58	41	10	48	18	49	47	84		1.00	− 0.1	7	6,032	n.	38	sw.	30	9	6	15	6.1	.....	.....
Mount Tamalpais	2,375	11	18	27.51	29.96	+ .01	60.0	− 4.1	86	7	69	38	2	51	30	49	38	51		0.02	− 0.4	1	12,083	nw.	92	nw.	8	21	6	3	2.2	.....	.....
Point Reyes Light	490	7	18	29.43	29.94	.....	51.1	− 1.7	61	27	55	44	11	47	10	.....	.....	.....		0.22	.....	1	17,694	nw.	85	nw.	19	11	6	13	5.7	.....	.....
Red Bluff	332	50	56	29.53	29.88	.00	73.4	− 2.3	102	15	86	47	28	60	40	55	39	36		1.14	+ 0.7	1	4,512	se.	26	nw.	20	19	6	5	2.7	.....	.....
Sacramento	69	106	117	29.83	29.90	+ .01	68.0	− 0.9	98	14	83	44	1	53	43	56	48	59		0.01	− 0.1	1	6,671	s.	31	nw.	20	28	1	1	0.8	.....	.....
San Francisco	155	209	213	29.80	29.97	+ .01	57.4	+ 0.4	76	6	64	47	14	51	25	51	48	76		T.	− 0.2	0	8,451	sw.	38	sw.	7	21	7	2	2.3	.....	.....
San Jose	141	12	110	29.83	29.98	.....	62.4	− 2.6	91	6	76	41	2	49	46	.....	.....	.....		T.	− 0.1	0	2,825	nw.	20	nw.	1	27	3	0	2.0	.....	.....
South Pacific Coast Region.							**64.4**	**− 1.7**											**68**	**0.00**	**− 0.1**								**2.8**		
Fresno	327	89	98	29.53	29.88	+ .03	73.2	− 2.6	103	15	89	46	1	57	40	56	41	39		0.00	− 0.1	0	7,243	nw.	28	nw.	27	27	3	0	1.1	.....	.....
Los Angeles	338	159	191	29.55	29.91	+ .01	63.6	− 0.9	80	30	72	51	1	55	24	57	53	76		0.00	− 0.1	0	3,963	sw.	20	sw.	3	16	14	0	3.3	.....	.....
San Diego	87	62	70	29.82	29.91	− .01	61.4	− 2.4	74	30	66	52	2	57	17	57	55	83		T.	0.0	0	4,922	nw.	21	s.	20	14	12	4	4.3	.....	.....
San Luis Obispo	201	32	40	29.77	29.99	+ .04	59.4	− 1.0	89	23	72	41	21	47	40	52	48	75		0.00	− 0.1	0	3,542	w.	18	w.	20	20	10	0	2.6	.....	.....
West Indies.																																			
San Juan, P. R	82	8	54	29.89	29.97	− .02	80.4	.....	91	14	86	73	12	75	15	.....	.....	.....		3.94	− 1.9	18	6,509	se.	36	ne.	22	3	19	8	6.1	.....	.....
Panama.																																			
Balboa Heights	118	7	97	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Colon	25	5	71	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....		.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1916, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated. 3 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex	26	7:30 p. m.	D. N. p. m.	0.98	8:58 p. m.	9:35 p. m.	0.06	0.06	0.11	0.20	0.35	0.49	0.60	0.69	0.73	.....	.....	.....	.....	.....	.....
Albany, N. Y	18			0.33														0.31			
Alpena, Mich	4	11:44 a. m.	6:45 p. m.	0.94	1:40 p. m.	1:56 p. m.	.13	.12	.32	.40	.42										
Amarillo, Tex	4	4:32 p. m.	9:27 p. m.	1.38	6:49 p. m.	7:13 p. m.	.13	.20	.66	.92	1.06	1.12									
Anniston, Ala	12			0.32														.30			
Asheville, N. C	24	12:35 p. m.	4:50 p. m.	0.77	12:42 p. m.	12:53 p. m.	.01	.23	.37	.39											
Atlanta, Ga	12	D. N. a. m.	7:38 a. m.	0.89	5:28 a. m.	5:41 a. m.	.33	.22	.32	.36											
	30	2:54 p. m.	3:25 p. m.	0.42	2:57 p. m.	3:11 p. m.	.01	.11	.28	.39											
Atlantic City, N. J	16			0.48														.39			
Augusta, Ga	6	8:50 p. m.	D. N. p. m.	1.12	9:00 p. m.	9:26 p. m.	.02	.14	.42	.51	.58	.97	1.00								
	15	7:25 p. m.	9:40 p. m.	1.05	7:32 p. m.	7:57 p. m.	.01	.25	.53	.59	.67	.90									
	23	5:00 p. m.	7:10 p. m.	1.28	5:51 p. m.	6:33 p. m.	.33	.19	.37	.48	.59	.67	.71	.76	.87	0.90					
	27	3:15 p. m.	7:00 p. m.	1.04	3:32 p. m.	4:24 p. m.	.05	.10	.20	.23	.25	.30	.33	.40	.58	.68	0.80	.86			
Baker, Oreg	19			0.74														.26			
Baltimore, Md	15–16			1.75														*			
Bentonville, Ark	11	5:00 a. m.	8:10 a. m.	1.16	5:04 a. m.	5:21 a. m.	.01	.36	.65	.80	.85										
Binghamton, N. Y	2–3			1.33														.31			
Birmingham, Ala	6	5:00 a. m.	6:15 a. m.	0.73	5:10 a. m.	5:56 a. m.	.02	.05	.16	.22	.24	.34	.42	.50	.52	.69	.71				
Bismarck, N. Dak	22–23			0.68														.31			
Block Island, R. I	17			1.10														.32			
Boise, Idaho	18	11:55 a. m.	9:25 p. m.	1.10	1:05 p. m.	1:39 p. m.	.14	.07	.13	.20	.34	.44	.50	.56							
Boston, Mass	17			1.51														.47			
Buffalo, N. Y	3	7:25 a. m.	8:20 a. m.	0.40	7:32 a. m.	7:41 a. m.	T.	.23	.38												
Burlington, Vt	5	5:15 p. m.	8:10 p. m.	0.52	7:24 p. m.	7:35 p. m.	.08	.15	.35	.39											
Cairo, Ill	2	5:53 p. m.	6:45 p. m.	1.20	6:00 p. m.	6:40 p. m.	.01	.07	.26	.39	.43	.63	.90	1.12	1.19						
	5–6	8:07 p. m.	D. N. a. m.	1.17	1:43 a. m.	1:55 a. m.	.55	.22	.47	.56											
	22	5:58 p. m.	7:55 p. m.	0.72	7:12 p. m.	7:34 p. m.	.17	.16	.35	.43	.49	.53									
	23	4:30 p. m.	7:52 p. m.	0.77	4:30 p. m.	4:55 p. m.	.00	.10	.25	.43	.34	.59									
Canton, N. Y	18	1:54 p. m.	4:10 p. m.	0.61	2:21 p. m.	2:44 p. m.	.05	.11	.16	.18	.39	.46									
Charles City, Iowa	1	2:53 p. m.	9:10 p. m.	2.55	3:13 p. m.	3:31 p. m.	.02	.16	.38	.47	.61										
					5:45 p. m.	6:19 p. m.	.89	.13	.40	.85	1.04	1.20	1.31	1.37							
Charleston, S. C	15	7:35 a. m.	12:55 p. m.	2.04	11:27 a. m.	12:07 p. m.	.14	.10	.35	.55	.78	1.14	1.34	1.60	1.81						
	27	12:14 p. m.	4:45 p. m.	3.47	12:41 p. m.	2:05 p. m.	.01	.06	.27	.57	.72	1.00	1.19	1.46	1.69	1.93	2.14	2.57	3.09	3.23	
	30–1	8:55 p. m.	D. N. a. m.	1.17	8:59 p. m.	9:18 p. m.	.01	.22	.56	.80	.91										
Charlotte, N. C	6	5:15 a. m.	8:57 a. m.	2.15	5:37 a. m.	6:25 a. m.	.01	.09	.27	.41	.53	.60	.88	1.20	1.69	1.88	1.92				
Chattanooga, Tenn	11–12	10:08 p. m.	2:15 a. m.	0.92	11:02 p. m.	11:26 p. m.	.12	.23	.33	.34	.41	.52									
	24–25	16:16 p. m.	1:57 a. m.	1.01	11:48 p. m.	12:40 a. m.	.12	.09	.16	.25	.33	.40	.50	.55	.64	.70	.75	.77			
Cheyenne, Wyo	10			0.24														.17			
Chicago, Ill	6–8			4.00														*			
Cincinnati, Ohio	2	6:25 p. m.	10:15 p. m.	0.74	8:23 p. m.	8:33 p. m.	.27	.20	.40												
Cleveland, Ohio	10	5:25 p. m.	6:45 p. m.	0.53	5:49 p. m.	6:04 p. m.	.01	.19	.38	.44											
Columbia, Mo	23	10:12 a. m.	11:27 a. m.	0.62	10:33 a. m.	11:04 a. m.	.06	.06	.12	.22	.32	.46	.51	.54							
Columbia, S. C	6–7	7:38 p. m.	D. N. a. m.	1.84	8:12 p. m.	8:54 p. m.	.02	.16	.41	.56	.71	.92	1.17	1.37	1.50	1.58					
	15	7:50 p. m.	8:38 p. m.	0.55	7:57 p. m.	8:08 p. m.	.01	.15	.50	.53											
	24	7:18 p. m.	9:55 p. m.	0.95	7:49 p. m.	8:19 p. m.	.29	.34	.45	.52	.60	.63									
Columbus, Ohio	2–3			0.96														.53			
Concord, N. H	16–17			0.94														.36			
Concordia, Kans	20	12:30 a. m.	5:00 p. m.	1.32	1:32 a. m.	2:04 a. m.	.16	.15	.26	.30	.39	.62	.80	.86							
	25	10:45 p. m.	11:52 p. m.	0.67	10:51 p. m.	11:11 p. m.	.01	.11	.30	.48	.59										
Corpus Christi, Tex	12	1:39 p. m.	3:22 p. m.	1.01	2:23 p. m.	2:46 p. m.	.10	.13	.45	.65	.81	.89									
Davenport, Iowa	6–8			1.78														*			
Dayton, Ohio	2	5:40 p. m.	8:44 p. m.	1.26	5:54 p. m.	6:10 p. m.	.05	.11	.22	.57	.63										
					8:23 p. m.	8:30 p. m.	.94	.22	.29												
Del Rio, Tex	15			0.05														.05			
Denver, Colo	11			0.07														.06			
Des Moines, Iowa	20			0.46														.20			
Detroit, Mich	8	1:08 p. m.	2:47 p. m.	0.42	1:56 p. m.	2:11 p. m.	.01	.08	.19	.35											
Devils Lake, N. Dak	22–23	12:05 p. m.	D. N. a. m.	1.11	8:36 p. m.	8:51 p. m.	.40	.18	.32	.45											
Dodge City, Kans	19–20	10:25 p. m.	D. N. a. m.	1.75	10:38 p. m.	12:12 a. m.	.01	.09	.19	.29	.36	.40	.49	.57	.72	.87	1.02	1.14	1.36	1.53	
Dubuque, Iowa	1	7:55 p. m.	10:25 p. m.	1.21	9:26 p. m.	9:59 p. m.	.05	.24	.50	.71	.87	.98	1.08	1.12							
Duluth, Minn	13	D. N. a. m.	10:30 a. m.	1.57	6:07 a. m.	6:42 a. m.	.68	.09	.20	.25	.31	.37	.45	.55							
Durango, Colo	4			T.														T.			
Eastport, Me	28			0.89														.50			
Elkins, W. Va	24–25			1.30														.52			
El Paso, Tex	‡																				
Erie, Pa	24	3:20 p. m.	4:10 p. m.	0.45	3:23 p. m.	3:38 p. m.	.04	.22	.30	.37											
Escanaba, Mich	4	10:50 a. m.	11:50 a. m.	0.94	10:59 a. m.	11:34 a. m.	.01	.06	.23	.48	.74	.78	.79	.88							
Eureka, Cal	27–28			0.44														.15			
Evansville, Ind	15	9:13 p. m.	10:45 p. m.	0.82	9:18 p. m.	9:46 p. m.	.01	.10	.21	.27	.39	.50	.56								
Flagstaff, Ariz	‡																				
Fort Smith, Ark	5	10:23 a. m.	2:14 p. m.	1.02	12:23 p. m.	12:42 p. m.	0.16	0.18	0.38	0.65	0.73										
Fort Wayne, Ind	6–7			1.78														*			
Fort Worth, Tex	14	6:34 a. m.	10:04 a. m.	1.72	6:47 a. m.	8:26 a. m.	.01	.11	.29	.37	.42	.47	.54	.57	.59	.59	.72	.93	1.16	1.62	
	14	10:32 p. m.	11:58 p. m.	1.08	10:35 p. m.	11:26 p. m.	.01	.15	.36	.52	.65	.70	.74	.84	.90	.75	1.01				
Fresno, Cal	‡																				
Galveston, Tex	7	5:20 a. m.	7:45 a. m.	1.24	5:43 a. m.	6:10 a. m.	.01	.14	.15	.23	.45	.66	.75								
	27	11:14 a. m.	5:35 p. m.	1.50	1:30 p. m.	2:03 p. m.	.02	.19	.53	.86	1.02	1.11	1.17	1.20							
Grand Haven, Mich	29	7:15 p. m.	D. N. p. m.	1.54	8:13 p. m.	9:35 p. m.	.19	.09	.12	.18	.22	.28	.34	.41	.44	.50	.57	.62	1.15	1.27	
Grand Junction, Colo	5																				
	18			T.														T.			
Grand Rapids, Mich	2	1:00 a. m.	4:15 a. m.	0.68	1:45 a. m.	1:59 a. m.	.08	.09	.25	.44											
Green Bay, Wis	12	12:59 p. m.	2:30 p. m.	0.81	1:08 p. m.	1:43 p. m.	.02	.07	22	.31	.37	.47	.70	.77							
Hannibal, Mo	20	3:14 p. m.	3:42 p. m.	0.45	3:21 p. m.	3:32 p. m.	.02	.23	.40	.43											
Harrisburg, Pa	15–18			1.41														*			
Hartford, Conn	17			1.22														*			
Hatteras, N. C	3	6:54 p. m.	9:40 p. m.	0.75	8:02 p. m.	8:25 p. m.	.21	.08	.12	.19	.37	.49									
Havre, Mont	21–22			1.06														*			
Helena, Mont	21			0.83														*			
Houghton, Mich	2			1.84														*			
Houston, Tex	27	1:51 p. m.	4:30 p. m.	0.60	2:03 p. m.	2:20 p. m.	.02	.12	.31	.44	.50										
Huron, S. Dak	12			1.47														.70			
Independence, Cal	‡																				
Indianapolis, Ind	20–21	9:20 p. m.	D. N. a. m.	1.18	10:48 p. m.	11:10 p. m.	.12	.07	.23	.44	.53	.57									
	5	5:53 p. m.	11:43 p. m.	0.93	8:59 p. m.	9:32 p. m.	.14	.09	.17	.28	.37	.44	.57	.64							
Iola, Kans	10–11	10:01 p. m.	6:42 a. m.	2.56	1:41 a. m.	2:26 a. m.	.53	.15	.33	.45	.50	.54	.61	.71	.73	.83					
					3:12 a. m.	3:58 a. m.	1.51	.05	.14	.24	.28	.32	.37	.44	.54	.66	.70				

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		3 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Jacksonville, Fla.	14	8:05 a. m.	11:25 a. m.	1.28	9:40 a. m.	10:26 a. m.	0.01	0.13	0.16	0.19	0.28	0.47	0.73	0.93	1.05	1.21	1.23	.....	.....	.....	.....
	18	1:30 p. m.	5:20 p. m.	0.84	2:31 p. m.	3:02 p. m.	.03	.06	.17	.43	.60	.71	.77	.80	.....	.....	.....	.....	.....	.....	.....
	24	11:54 a. m.	2:25 p. m.	1.07	11:56 a. m.	12:36 p. m.	.01	.30	.37	.39	.39	.41	.78	.92	1.02	.....	.....	.....	.....	.....	.....
	29	3:43 p. m.	5:15 p. m.	0.88	4:05 p. m.	4:27 p. m.	.03	.27	.43	.59	.73	.79	.....	.....	.....	.....	.....	.....	.....	.....	.....
Kalispell, Mont.	18–20	.....	.....	1.68	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.31	.....	.....	.....
Kansas City, Mo.	5–6	.....	.....	2.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Keokuk, Iowa.	20	2:30 p. m.	4:50 p. m.	1.40	3:36 p. m.	4:04 p. m.	.20	.17	.50	.83	1.04	1.10	1.17	.....	.....	.....	.....	.....	.....	.....	.....
Key West, Fla.	13	9:29 a. m.	10:30 a. m.	0.98	9:42 a. m.	10:10 a. m.	.02	.21	.48	.65	.81	.90	.95	.....	.....	.....	.....	.....	.....	.....	.....
Knoxville, Tenn.	11–12	5:50 p. m.	7:50 a. m.	1.72	6:20 p. m.	6:45 p. m.	.01	*	*	*	*	.65	.....	.....	.....	.....	.....	.....	.....	.....	.....
La Crosse, Wis.	25–26	11:27 p. m.	D. N. a. m.	0.68	11:28 p. m.	11:37 p. m.	.01	.30	.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Lander, Wyo.	21	.....	.....	0.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.06	.....	.....	.....
Lansing, Mich.	29–30	.....	.....	1.58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.40	.....	.....	.....
Lewiston, Idaho.	25–26	.....	.....	0.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.30	.....	.....	.....
Lexington, Ky.	2	10:12 p. m.	D. N. p. m.	0.82	10:12 p. m.	10:50 p. m.	.00	.17	.28	.33	.40	.50	.59	.66	.78	.....	.....	.....	.....	.....	.....
	18	3:45 p. m.	5:15 p. m.	0.71	4:13 p. m.	4:48 p. m.	.01	.14	.24	.30	.39	.44	.55	.68	.....	.....	.....	.....	.....	.....	.....
Lincoln, Nebr.	20	.....	.....	0.78	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Little Rock, Ark.	5	4:10 p. m.	6:10 p. m.	1.07	4:26 p. m.	4:49 p. m.	.04	.06	.16	.37	.64	.74	.....	.....	.....	.....	.....	.....	.....	.....	.....
	23	3:58 p. m.	4:45 p. m.	0.72	4:07 p. m.	4:23 p. m.	.01	.19	.51	.68	.70	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Los Angeles, Cal.	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Louisville, Ky.	18	2:58 p. m.	6:47 p. m.	1.65	5:06 p. m.	5:28 p. m.	.05	.24	.37	.51	.74	.82	.....	.....	.....	.....	.....	.....	.....	.....	.....
					6:10 p. m.	6:35 p. m.	1.02	.15	.27	.40	.50	.59	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ludington, Mich.	8–9	.....	.....	1.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.32	.....	.....	.....
Lynchburg, Va.	29–30	10:30 p. m.	12:40 a. m.	1.73	11:06 p. m.	12:01 a. m.	.08	.06	.10	.19	.53	.83	1.09	1.27	1.43	1.50	1.56	1.63	.....	.....	.....
Macon, Ga.	22–23	7:36 p. m.	D. N. a. m.	1.18	7:46 p. m.	8:15 p. m.	.03	.08	.14	.27	.63	.90	.99	.....	.....	.....	.....	.....	.....	.....	.....
Madison, Wis.	1	9:50 p. m.	D. N. p. m.	0.87	10:38 p. m.	11:18 p. m.	.09	.09	.13	.22	.29	.40	.45	.62	.77	.....	.....	.....	.....	.....	.....
Marquette, Mich.	1–2	1:44 p. m.	6:14 p. m.	4.46	6:40 a. m.	.....	1.25	.05	.08	.12	.18	.23	.28	.35	.42	.46	.50	.....	.....	.....	.....
					.....	.....		.56	.60	.65	.71	.76	.81	.86	.91	.98	1.04	.....	.....	.....	.....
					.....	.....		1.11	1.23	1.30	1.38	1.46	1.55	1.61	1.69	1.75	1.82	.....	.....	.....	.....
					.....	9:50 a. m.		1.89	1.96	2.02	2.09	2.19	2.26	2.32	2.37	.....	.....	.....	.....	.....	.....
Memphis, Tenn.	19	7:30 p. m.	D. N. p. m.	0.74	7:50 p. m.	8:14 p. m.	.01	.10	.24	.32	.54	.66	.....	.....	.....	.....	.....	.....	.....	.....	.....
Meridian, Miss.	27	10:52 a. m.	11:45 a. m.	1.03	10:53 a. m.	11:17 a. m.	T.	.24	.57	.74	.90	1.01	.....	.....	.....	.....	.....	.....	.....	.....	.....
Miami, Fla.	16	1:23 p. m.	4:00 p. m.	2.33	1:53 p. m.	3:09 p. m.	.01	.22	.45	.62	.69	.76	.78	.88	1.11	1.37	1.53	1.70	1.99	.....	.....
	18	D. N. a. m.	D. N. a. m.	1.07	1:56 a. m.	2:00 a. m.	.03	.06	.17	.44	.57	.68	.80	.93	.....	.....	.....	.....	.....	.....	.....
	29	D. N. a. m.	6:15 a. m.	1.24	5:29 a. m.	6:04 a. m.	.10	.30	.48	.79	.95	.95	.97	1.14	.....	.....	.....	.....	.....	.....	.....
Milwaukee, Wis.	6–8	.....	.....	3.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Minneapolis, Minn.	29	12:55 a. m.	D. N. a. m.	1.40	12:55 a. m.	1:59 a. m.	.00	.12	.30	.48	.56	.61	.64	.69	.71	.74	.75	.98	1.09	.....	.....
Mobile, Ala.	28	3:28 p. m.	6:10 p. m.	1.27	3:32 p. m.	4:10 p. m.	.01	.10	.16	.32	.53	.84	1.04	1.15	1.19	.....	.....	.....	.....	.....	.....
Modena, Utah.	10	.....	.....	0.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.....	.....	.....
Montgomery, Ala.	12	2:35 p. m.	6:20 p. m.	0.91	3:36 p. m.	4:10 p. m.	.01	.14	.29	.44	.64	.73	.80	.85	.....	.....	.....	.....	.....	.....	.....
	26	2:12 p. m.	3:35 p. m.	0.71	2:27 p. m.	2:44 p. m.	.01	.25	.51	.63	.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Moorehead, Minn.	28	5:40 p. m.	11:15 p. m.	1.88	5:52 p. m.	6:27 p. m.	.03	.13	.42	.64	.91	1.07	1.28	1.36	.....	.....	.....	.....	.....	.....	.....
Mount Tamalpais, Cal.	30	.....	.....	0.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.....	.....	.....
Nantucket, Mass.	17–18	.....	.....	1.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.71	.....	.....	.....
Nashville, Tenn.	11	12:50 p. m.	8:45 p. m.	1.51	7:46 p. m.	8:16 p. m.	.75	.09	.13	.17	.40	.57	.70	.....	.....	.....	.....	.....	.....	.....	.....
New Haven, Conn.	16–17	.....	.....	1.26	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.58	.....	.....	.....
New Orleans, La.	12	11:39 a. m.	1:25 p. m.	1.57	12:21 p. m.	12:46 p. m.	.07	.20	.52	.90	1.31	1.38	.....	.....	.....	.....	.....	.....	.....	.....	.....
	17	5:25 p. m.	6:00 p. m.	0.52	5:36 p. m.	5:56 p. m.	.02	.09	.27	.39	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	23	8:30 p. m.	9:45 p. m.	0.70	8:35 p. m.	9:00 p. m.	.01	.08	.27	.40	.50	.55	.....	.....	.....	.....	.....	.....	.....	.....	.....
	25	D. N. a. m.	6:05 a. m.	3.29	3:59 a. m.	5:21 a. m.	.14	.20	.39	.74	1.30	1.52	1.71	1.80	1.97	2.21	2.43	2.81	3.02	3.08	.....
New York, N. Y.	17	3:10 p. m.	3:34 p. m.	0.50	3:23 p. m.	3:33 p. m.	T.	.22	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Norfolk, Va.	7	.....	.....	0.45	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.40	.....	.....	.....
Northfield, Vt.	27–28	.....	.....	0.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.52	.....	.....	.....
North Head, Wash.	27	.....	.....	0.34	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.20	.....	.....	.....
North Platte, Nebr.	10	D. N. a. m.	6:05 a. m.	0.67	3:44 a. m.	3:54 a. m.	.09	.15	.39	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oklahoma, Okla.	12	1:05 a. m.	4:20 a. m.	0.76	1:34 a. m.	1:57 a. m.	.04	.08	.22	.34	.47	.53	.....	.....	.....	.....	.....	.....	.....	.....	.....
	14	2:05 a. m.	8:10 a. m.	0.99	2:13 a. m.	2:33 a. m.	.01	.23	.50	.59	.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	23	8:52 p. m.	11:30 p. m.	2.23	9:03 p. m.	10:02 p. m.	.01	.15	.42	.82	.98	1.27	1.63	1.78	1.82	1.87	1.91	2.11	.....	.....	.....
Omaha, Nebr.	25	9:30 p. m.	12 mid.	1.10	9:59 p. m.	10:16 p. m.	.01	.19	.64	.85	.87	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Oswego, N. Y.	3	11:32 a. m.	3:05 p. m.	0.63	12:03 p. m.	12:24 p. m.	.01	.20	.24	.35	.46	.50	.....	.....	.....	.....	.....	.....	.....	.....	.....
Palestine, Tex.	15	.....	.....	0.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.26	.....	.....	.....
Parkersburg, W. Va.	21	.....	.....	1.15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.53	.....	.....	.....
Pensacola, Fla.	13	12:50 p. m.	4:50 p. m.	2.45	1:12 p. m.	2:19 p. m.	.01	.07	.12	.18	.48	.78	1.22	1.56	1.78	1.91	2.00	2.20	2.39	.....	.....
Peoria, Ill.	20	.....	.....	1.03	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.46	.....	.....	.....
Philadelphia, Pa.	7–8	.....	.....	1.72	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.40	.....	.....	.....
Phoenix, Ariz.	‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pierre, S. Dak.	19–20	.....	.....	0.66	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.33	.....	.....	.....
Pittsburgh, Pa.	2–3	.....	.....	1.12	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.60	.....	.....	.....
Pocatello, Idaho.	4	.....	.....	0.20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.14	.....	.....	.....
Point Reyes Light, Cal.	30	.....	.....	0.22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.05	.....	.....	.....
Port Huron, Mich.	2	.....	.....	0.32	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.31	.....	.....	.....
Portland, Me.	8–12	.....	.....	3.06	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Portland, Oreg.	29–30	.....	.....	0.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Providence, R. I.	17	.....	.....	2.27	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.63	.....	.....	.....
Pueblo, Colo.	11	3:58 p. m.	5:34 p. m.	0.89	4:39 p. m.	5:02 p. m.	.01	.06	.32	.55	.81	.87	.....	.....	.....	.....	.....	.....	.....	.....	.....
Raleigh, N. C.	3	3:50 p. m.	5:46 p. m.	0.65	3:56 p. m.	4:11 p. m.	.02	.25	.47	.59	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	6–7	8:50 p. m.	D. N. a. m.	1.45	8:56 p. m.	9:33 p. m.	.01	.14	.26	.34	.50	.62	.68	.77	.83	.....	.....	.....	.....	.....	.....
	15	10:55 a. m.	7:29 p. m.	6.23	6:03 p. m.	6:30 p. m.	.52	.11	.14	.25	.33	.57	.69	.....	.....	.....	.....	.....	.....	.....	.....
	24–25	7:27 p. m.	D. N. a. m.	1.27	7:41 p. m.	8:02 p. m.	.01	.13	.40	.61	.80	.85	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rapid City, S. Dak.	12	.....	.....	0.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
Reading, Pa.	3	4:21 p. m.	5:32 p. m.	0.48	4:46 p. m.	5:02 p. m.	.02	.11	.30	.39	.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Red Bluff, Cal.	30	.....	.....	1.14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.12	.....	.....	.....
Reno, Nev.	21	.....	.....	0.11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.05	.....	.....	.....
Richmond, Va.	24	7:05 p. m.	9:26 p. m.	0.82	7:17 p. m.	7:43 p. m.	.01	.24	.40	.42	.49	.66	.69	.....	.....	.....	.....	.....	.....	.....	.....
	24–25	9:55 p. m.	3:00 a. m.	1.51	9:59 p. m.	10:31 p. m.	.01	.15	.33	.36	.49	.83	1.14	1.19	.....	.....	.....	.....	.....	.....	.....
	28	9:07 p. m.	9:54 p. m.	0.93	9:10 p. m.	9:37 p. m.	.02	.20	.42	.64	.76	.84	.88	.....	.....	.....	.....	.....	.....	.....	.....
Rochester, N. Y.	2	8:55 p. m.	10:45 p. m.	0.70	9:30 p. m.	9:50 p. m.	.02	.07	.27	.40	.58	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	24	3:13 p. m.	6:25 p. m.	1.21	5:04 p. m.	5:21 p. m.	.26	.14	.43	.61	.67	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Roseburg, Oreg.	30	.....	.....	0.19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.12	.....	.....	.....
Roswell, N. Mex.	12	.....	.....	0.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.44	.....	.....	.....
Sacramento, Cal.	30	.....	.....	0.01	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.01	.....	.....	.....
Saginaw, Mich.	2	3:44 a. m.	6:23 a. m.	0.60	4:22 a. m.	4:44 a. m.	.05	.19	.33	.38	.48	.51	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Joseph, Mo.	5–6	.....	.....	1.75	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	*	.....	.....	.....
St. Louis, Mo.	2	8:34 a. m.	9:32 a. m.	0.80	8:41 a. m.	9:01 a. m.	.01	.26	.53	.69	.76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Paul, Minn.	25	5:28 p. m.	9:30 p. m.	0.85	6:32 p. m.	6:45 p. m.	.11	.18	.43	.49	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Salt Lake City, Utah.	21	.....	.....	0.44	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.09	.....	.....	.....
San Antonio, Tex.	15	.....	.....	0.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.27	.....	.....	.....
San Diego, Cal.	20	.....	.....	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T.	.....	.....	.....
Sand Key, Fla.	2	.....	.....	0.29	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.27	.....	.....	.....
Sandusky, Ohio.	16	1:50 p. m.	5:30 p. m.	0.81	1:55 p. m.	2:27 p. m.	T.	.13	.21	.25	.31	.44	.45	.58	.....	.....	.....	.....	.....	.....	.....
San Francisco, Cal.	30	.....	.....	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T.	.....	.....	.....
San Jose, Cal.	27	.....	.....	T.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	T.	.....	.....	.....

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during June, 1916, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration. From—	Total duration. To—	Total amount of precipitation.	Excessive rate. Began—	Excessive rate. Ended—	Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated. 3 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
San Luis Obispo, Cal.	‡																				
Santa Fe, N. Mex.	4			0.38														0.38			
Sault Ste. Marie, Mich.	16–18			1.39														*			
Savannah, Ga.	28	12:33 p. m.	1:50 p. m.	0.65	12:41 p. m.	1:01 p. m.	0.01	0.27	0.44	0.55	0.60										
Scranton, Pa.	27	9:15 p. m.	D. N. p. m.	1.98	9:33 p. m.	10:12 p. m.	.08	.05	.21	.34	.64	0.86	0.92	1.01	1.07						
Seattle, Wash.	20			0.44																	
Sheridan, Wyo.	4			0.33														.33			
Shreveport, La.	5	3:25 p. m.	4:08 p. m.	0.62	3:45 p. m.	4:06 p. m.	.03	.12	.24	.41	.58	.59									
	24	4:00 a. m.	5:50 a. m.	0.90	4:23 a. m.	4:39 a. m.	.07	.19	.36	.51	.57										
Sioux City, Iowa.	22–23	8:15 p. m.	D. N. a. m.	0.51	8:50 p. m.	9:00 p. m.	.02	.19	.31									*			
Spokane, Wash.	24			0.29														.25			
Springfield, Ill.	6	7:50 a. m.	4:50 p. m.	0.71	9:14 a. m.	9:43 a. m.	.03	.08	.20	.28	.37	.42	.51								
Springfield, Mo.	5			1.56														*			
Syracuse, N. Y.	24	7:15 p. m.	8:30 p. m.	0.72	7:53 p. m.	8:25 p. m.	.03	.08	.20	.36	.46	.53	.66	.69							
Tacoma, Wash.	30			0.41														.12			
Tampa, Fla.	8	7:08 a. m.	9:28 a. m.	1.33	7:30 a. m.	8:12 a. m.	.08	.20	.37	.53	.70	.83	.91	1.01	1.13	1.18					
	18	5:45 p. m.	6:28 p. m.	1.15	5:48 p. m.	6:14 p. m.	.01	.38	.71	.83	1.01	1.09	1.12								
Tatoosh Island, Wash.	27–30			1.01														.13			
Taylor, Tex.	15			0.44														.21			
Terre Haute, Ind.	20–21	7:54 p. m.	D. N. a. m.	1.64	9:00 p. m.	9:28 p. m.	.20	.25	.41	.80	1.05	1.27	1.34								
Thomasville, Ga.	4	4:35 p. m.	6:20 p. m.	1.22	5:04 p. m.	5:37 p. m.	.02	.37	.69	.85	.88	.90	1.06	1.17							
Toledo, Ohio.	17–18	10:00 p. m.	D. N. a. m.	0.47	11:06 p. m.	11:10 p. m.	.01	.20	.34												
Tonopah, Nev.	‡																				
Topeka, Kans.	26	12:35 a. m.	D. N. a. m.	0.70	12:48 a. m.	1:14 a. m.	.01	.12	.26	.35	.44	.51	.55								
Valentine, Nebr.	12	2:35 p. m.	5:35 p. m.	0.69	3:42 p. m.	4:02 p. m.	.08	.11	.37	.51	.58										
	17	8:10 p. m.	9:40 p. m.	0.59	8:57 p. m.	9:14 p. m.	.01	.21	.38	.50	.56										
Vicksburg, Miss.	24	D. N. a. m.	9:20 a. m.	2.17	5:38 a. m.	6:14 a. m.	.13	.05	.10	.24	.58	.66	.72	.80	.83						
					6:50 a. m.	7:12 a. m.	1.01	.11	.40	.55	.68	.73									
Walla Walla, Wash.	25–26			1.13														.36			
Washington, D. C.	10	6:45 p. m.	10:25 p. m.	2.18	7:01 p. m.	7:54 p. m.	.01	.08	.27	.59	.81	1.11	1.40	1.61	1.63	1.65	1.73	1.85			
Wichita, Kans.	5	12:30 a. m.	7:40 p. m.	4.76	11:36 a. m.	12:30 p. m.	2.73	.14	.23	.31	.43	.48	.53	.59	.72	.82	.93	1.02			
	11	12:50 a. m.	5:50 a. m.	1.01	1:01 a. m.	1:29 a. m.	.01	.13	.22	.25	.38	.47	.52								
	20	D. N. a. m.	D. N. a. m.	1.05	1:27 a. m.	11:56 a. m.	.02	.11	.39	.61	.71	.76	.82								
Williston, N. Dak.	29	9:45 p. m.	11:35 p. m.	0.98	10:05 p. m.		.01	.40	.65	.85	.90										
Wilmington, N. C.	6–7	11:58 p. m.	D. N. a. m.	1.14	12:03 a. m.	12:55 a. m.	.03	.08	.10	.22	.36	.49	.57	.65	.70	.77	.87	.92			
	25	12:24 p. m.	1:55 p. m.	1.01	12:51 p. m.	1:08 p. m.	.05	.18	.40	.70	.77										
		3:40 p. m.	8:15 p. m.	1.84	4:39 p. m.	5:19 p. m.	.01	.34	.73	.94	1.05	1.17	1.26	1.31	1.37						
	30	3:38 p. m.	5:55 p. m.	1.44	3:45 p. m.	4:20 p. m.	.01	.10	.21	.51	.78	.98	1.20	1.31							
Winnemucca, Nev.	‡																				
Wytheville, Va.	24	12:08 p. m.	2:30 p. m.	0.59	1:01 p. m.	1:20 p. m.	.08	.08	.23	.31	.40										
Yankton, S. Dak.	11	7:40 a. m.	10:45 a. m.	1.25	7:55 a. m.	8:17 a. m.	.04	.25	.45	.48	.55	.62									
	22	6:40 p. m.	10:15 p. m.	1.39	6:57 p. m.	7:32 p. m.	.02	.11	.33	.49	.62	.80	.92	1.00							
Yellowstone Park, Wyo.	20–21			1.18														*			

* Self-register not working. † Record partly estimated. ‡ No precipitation occurred during month.

TABLE III.—*Data furnished by the Canadian Meteorological Service, June, 1916.*

Stations.	Altitude above M. S. L.* Jan. 1, 1916.	Pressure. Station reduced to mean of 24 hours.	Pressure. Sea level reduced to mean of 24 hours.	Pressure. Departure from normal.	Temperature of the air. Mean max.+ mean min. ÷2.	Temperature of the air. Departure from normal.	Temperature of the air. Mean maximum.	Temperature of the air. Mean minimum.	Temperature of the air. Highest.	Temperature of the air. Lowest.	Precipitation. Total.	Precipitation. Departure from normal.	Precipitation. Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	°*F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.87	30.01	+0.10	53.2	+1.6	61.0	45.4	78	36	1.82	−1.78	.....
Sydney, C. B. I.	48	29.96	*30.00*	+ .05	55.8	+0.4	65.7	45.9	78	32	3.46	+0.23	.....
Halifax, N. S.	88	29.90	*30.00*	+ .05	57.1	−0.6	66.3	47.9	80	37	5.31	+1.55	.....
Yarmouth, N. S.	65	29.89	29.96	+ .01	54.9	−0.1	62.8	46.9	71	41	6.72	+3.96	.....
Charlottetown, P. E. I.	38	29.93	29.97	+ .05	59.2	+1.8	66.7	51.7	75	41	2.55	−0.12	.....
Chatham, N. B.	28	29.95	*29.97*	+ .08	60.3	+0.3	69.8	50.8	82	37	4.42	+0.96	.....
Father Point, Que.	20	29.90	29.92	+ .05	55.1	+2.1	62.6	47.6	80	40	3.48	+0.50	.....
Quebec, Que.	296	29.62	29.94	+ .02	61.3	+0.1	69.3	53.4	83	44	5.38	−1.73	.....
Montreal, Que.	187	29.71	29.91	− .03	63.2	−1.7	71.1	55.4	80	49	4.20	+0.67	.....
Stonecliffe, Ont.	489	29.30	*29.90*	− .04	60.0	−1.6	71.3	48.7	85	33	3.05	−0.11	.....
Ottawa, Ont.	236	29.65	*29.91*	− .03	61.7	−3.6	70.0	53.3	80	42	4.20	+1.28	.....
Kingston, Ont.	285	29.62	29.93	− .04	60.4	−3.0	67.5	53.3	74	42	6.20	+3.77	.....
Toronto, Ont.	379	29.50	*29.90*	− .07	60.1	−3.3	69.1	51.2	78	40	4.29	+1.49	.....
White River, Ont.	1,244	28.55	*29.85*	− .09	52.8	−5.9	65.7	39.9	79	28	5.95	+3.73	.....
Port Stanley, Ont.	592	29.28	29.92	− .05	59.8	−4.0	68.6	51.0	75	35	3.54	+0.81	.....
Southampton, Ont.	656	29.21	.....	.....	57.5	−2.9	66.4	48.6	81	36	5.95	+3.60	.....
Parry Sound, Ont.	688	29.22	29.90	− .06	59.5	−2.2	69.0	50.1	80	34	3.18	+0.76	.....
Port Arthur, Ont.	644	29.17	29.88	− .06	54.6	−1.8	63.8	45.4	76	36	3.03	+0.30	.....
Winnipeg, Man.	760	29.05	29.87	− .02	58.3	−3.9	69.1	47.5	80	34	4.12	+0.83	.....
Minnedosa, Man.	1,690	28.08	29.87	− .02	55.5	−4.1	66.0	44.9	78	32	3.55	+0.55	.....
Qu'Appelle, Sask.	2,115	27.60	29.82	− .05	55.7	−4.2	66.1	45.3	78	34	4.10	+0.68	.....
Medicine Hat, Alberta.	2,144	27.59	*29.84*	− .01	61.3	−0.7	73.6	49.1	87	38	4.09	+1.33	.....
Swift Current, Sask.	2,392	27.29	*29.83*	− .04	56.3	−3.7	68.1	44.5	79	28	4.05	+1.38	.....
Calgary, Alberta.	3,428	26.40	*29.89*	+ .05	56.1	+0.1	68.5	43.8	82	34	1.46	−0.99	.....
Banff, Alberta.	4,521	25.37	29.89	+0.05	51.3	−0.2	63.8	38.9	79	28	2.65	−0.68	.....
Edmonton, Alberta.	2,150	27.60	*29.86*	+ .02	56.0	−0.9	68.0	44.0	77	29	2.62	−0.24	.....
Prince Albert, Sask.	1,450	28.31	*29.85*	− .02	56.2	−1.5	67.0	45.5	77	30	2.60	+0.09	.....
Battleford, Sask.	1,592	28.12	*29.84*	− .02	57.2	−2.3	68.7	45.7	78	32	3.66	+0.35	.....
Kamloops, B. C.	1,262	28.70	29.97	+ .10	63.8	0.0	75.9	51.6	95	38	2.82	+1.40	.....
Victoria, B. C.	230	29.79	30.04	+ .03	56.4	+0.1	64.2	48.5	81	44	0.52	−0.68	.....
Barkerville, B. C.	4,180	25.72	30.01	+ .14	50.3	−0.4	62.7	37.9	75	24	2.86	−0.62	.....
Hamilton, Bermuda.	151	29.92	30.08	− .04	73.0	−2.0	78.8	67.3	82	62	2.14	−3.81	.....

* The altitudes given were furnished by the Director, Canadian Meteorological Service, March 9, 1916, and refer to cisterns of barometers at the respective stations. Where sea-level pressures and departures are *italicized* new reduction factors are in course of computation.—C. A., Jr.

Chart I. Hydrographs of Several Principal Rivers, June, 1916.

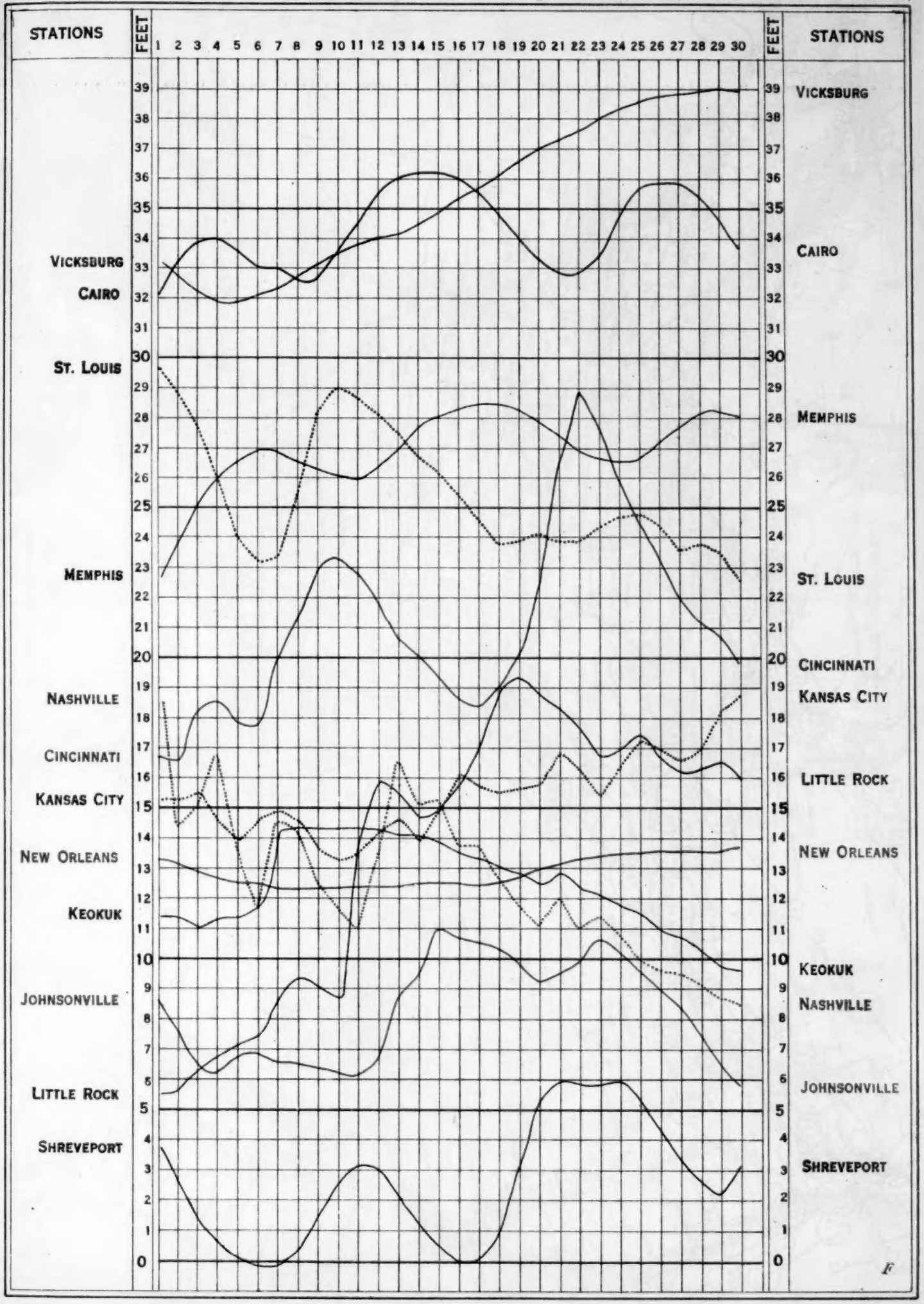


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Chart II. Tracks of Centers of High Areas, June, 1916.

(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, June, 1916.

(Plotted by R. H. Weightman.)

Chart III. Tracks of Centers of Low Areas, June, 1916.

(Plotted by R. H. Weightman.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, June, 1916.

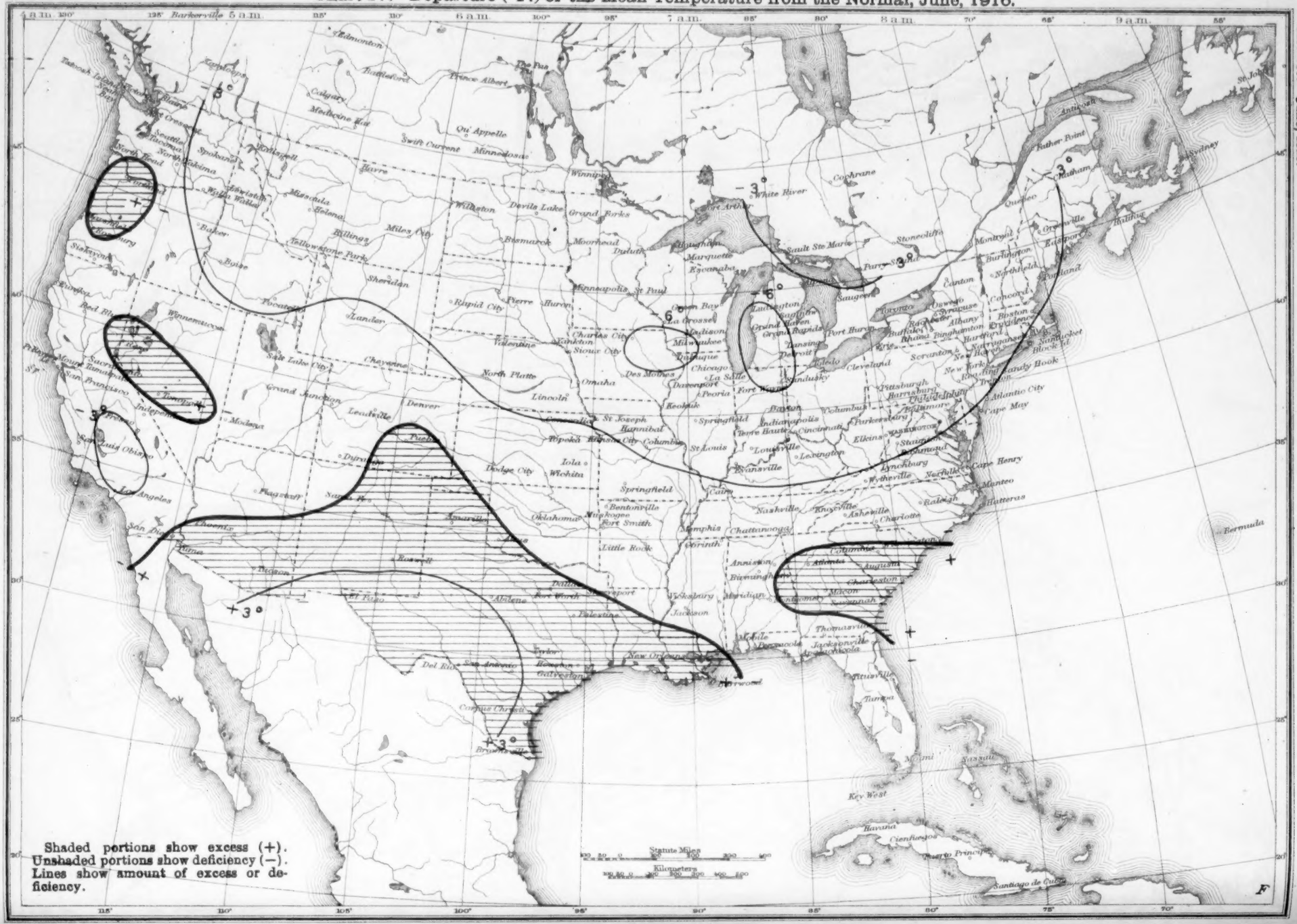

Shaded portions show excess (+).
Unshaded portions show deficiency (−).
Lines show amount of excess or deficiency.
Statute Miles
Kilometers

Chart V. Total Precipitation, June, 1916.

Chart V. Total Precipitation, June, 1916.

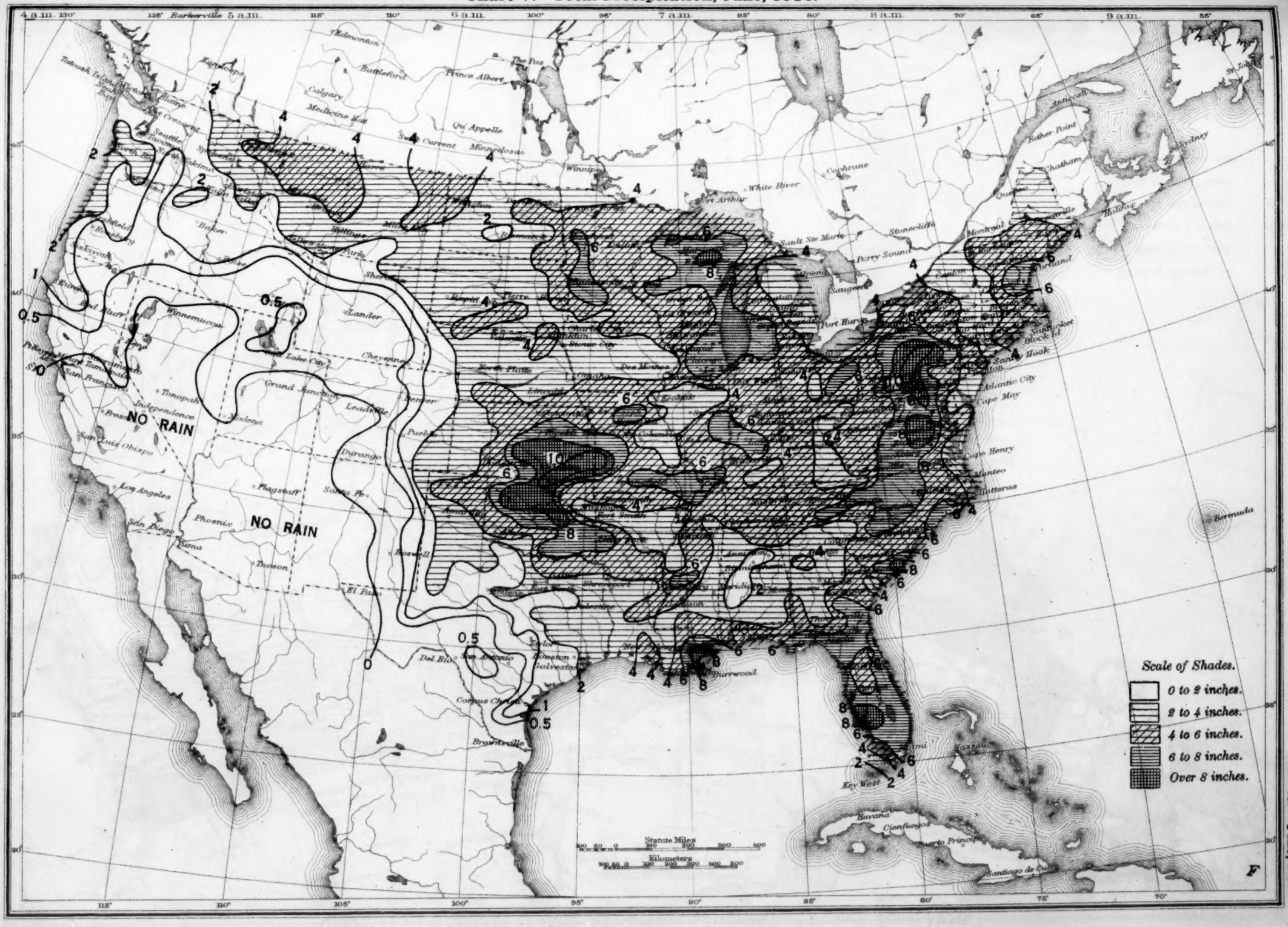


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, June, 1916.

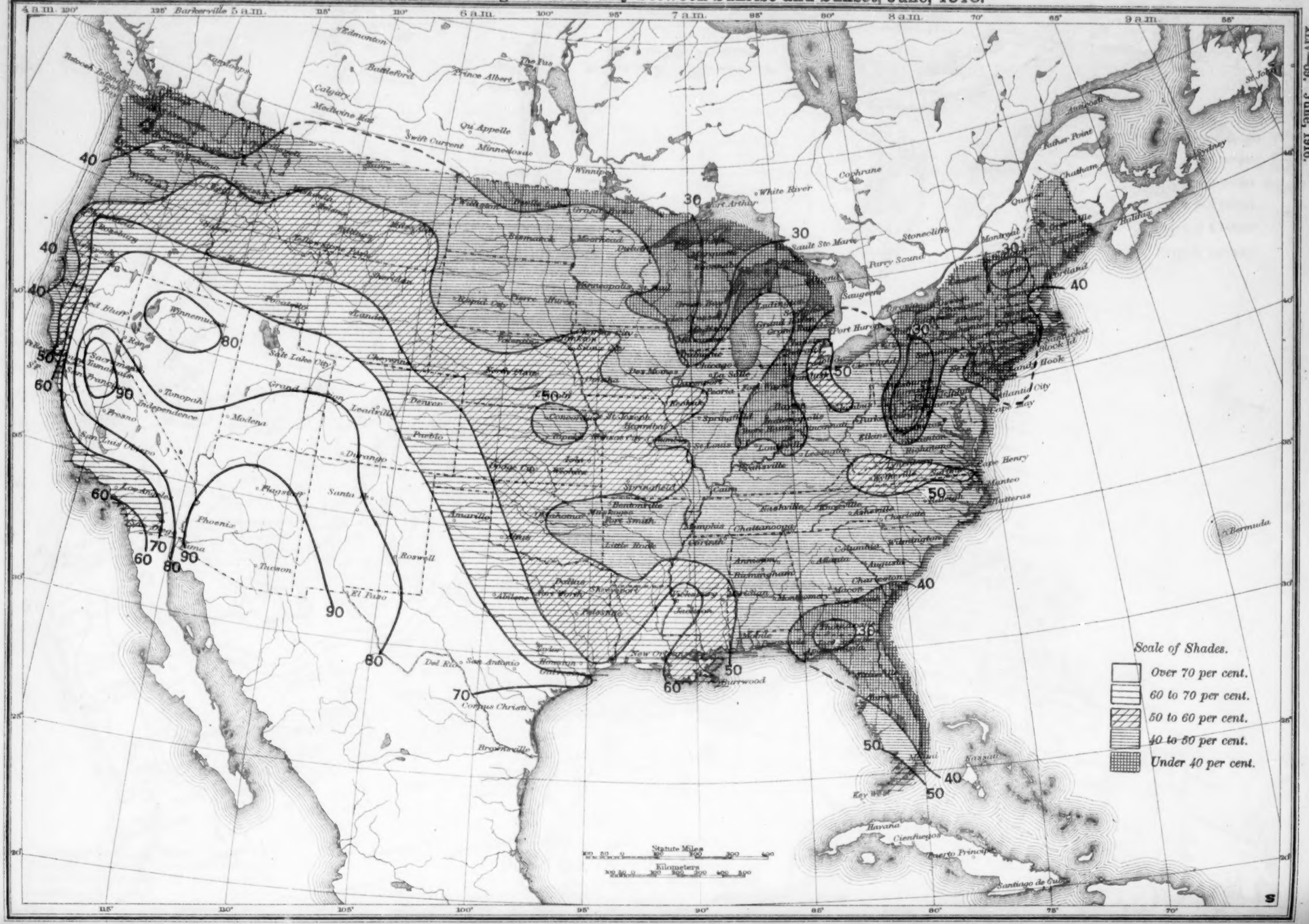


Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, June, 1916.

Chart VII. Isobars and Isotherms at Sea Level; Prevailing Winds, June, 1916.

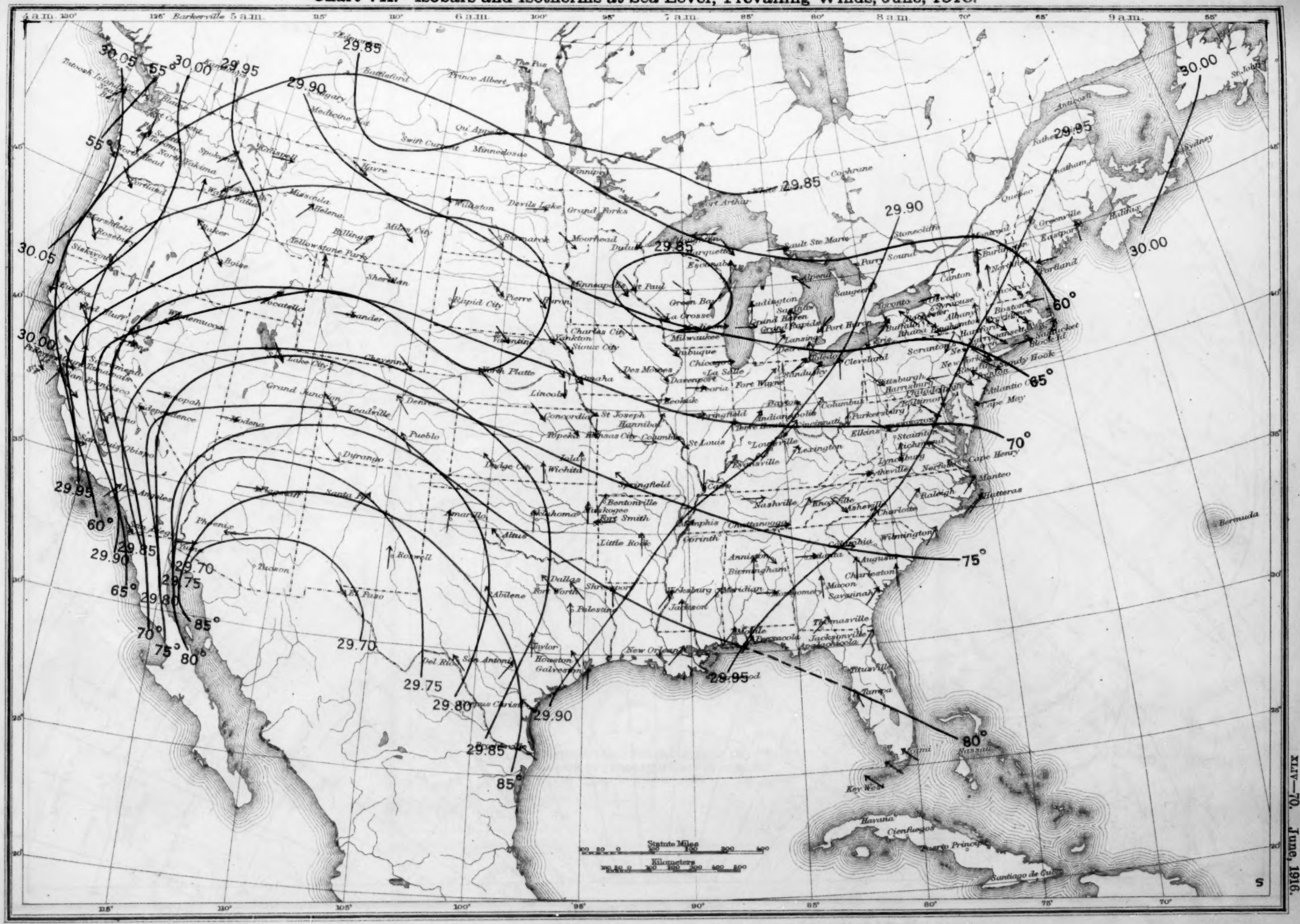
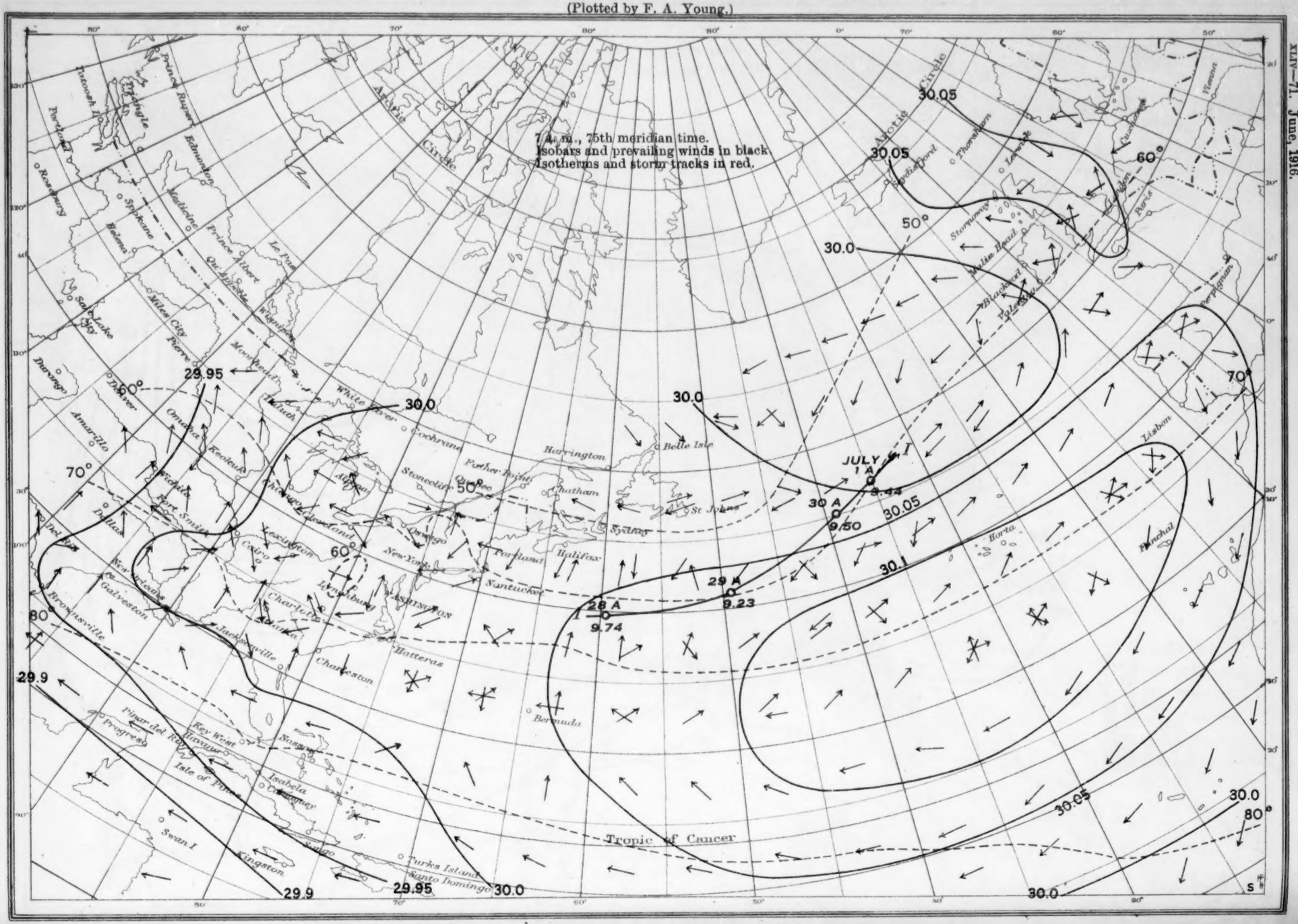


Chart IX. Means of Meteorological Data for North Atlantic Ocean, June, 1915.

(Plotted by F. A. Young.)



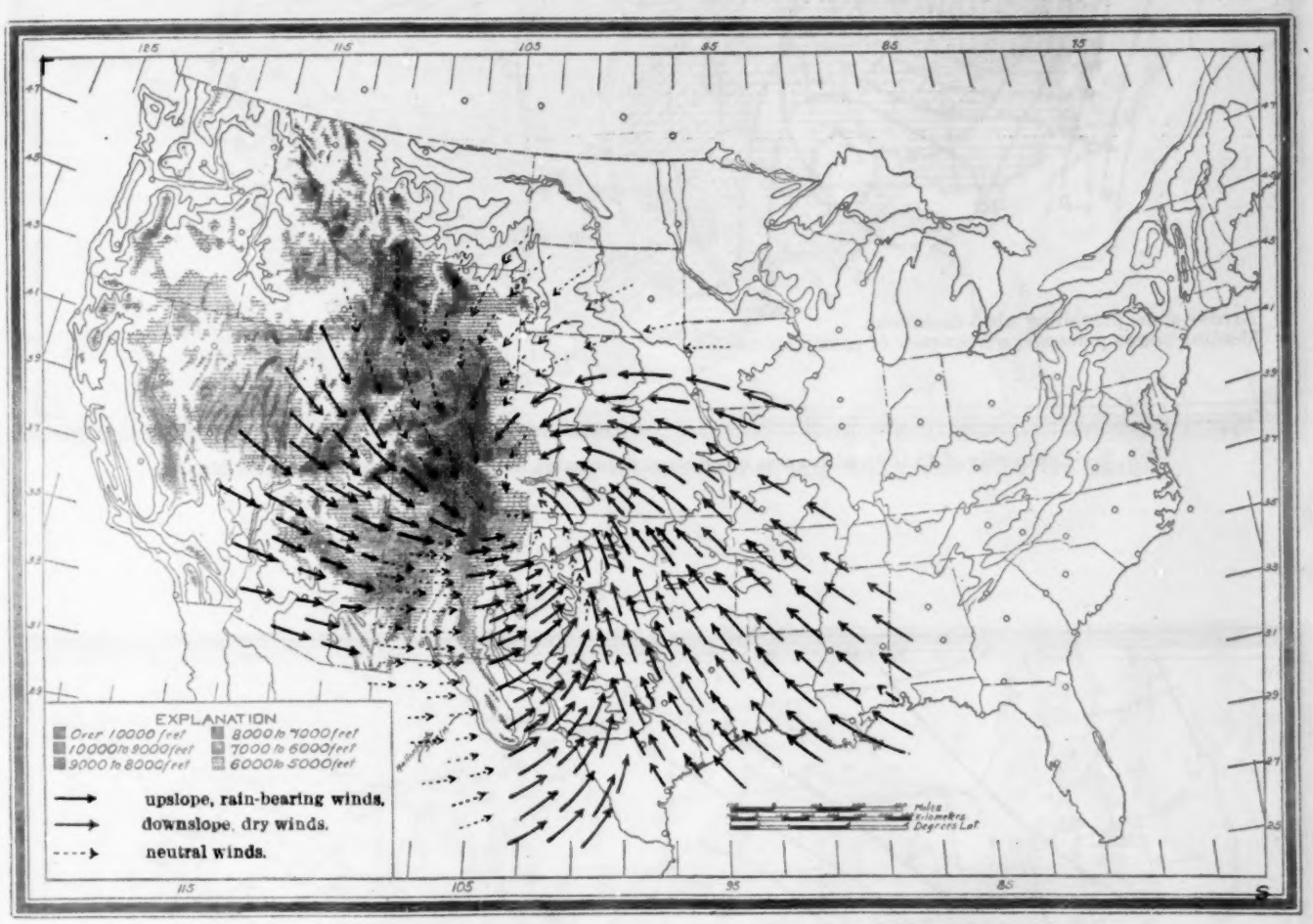


FIG. 1.—Ideal surface circulation about a LOW centered near northeastern New Mexico.

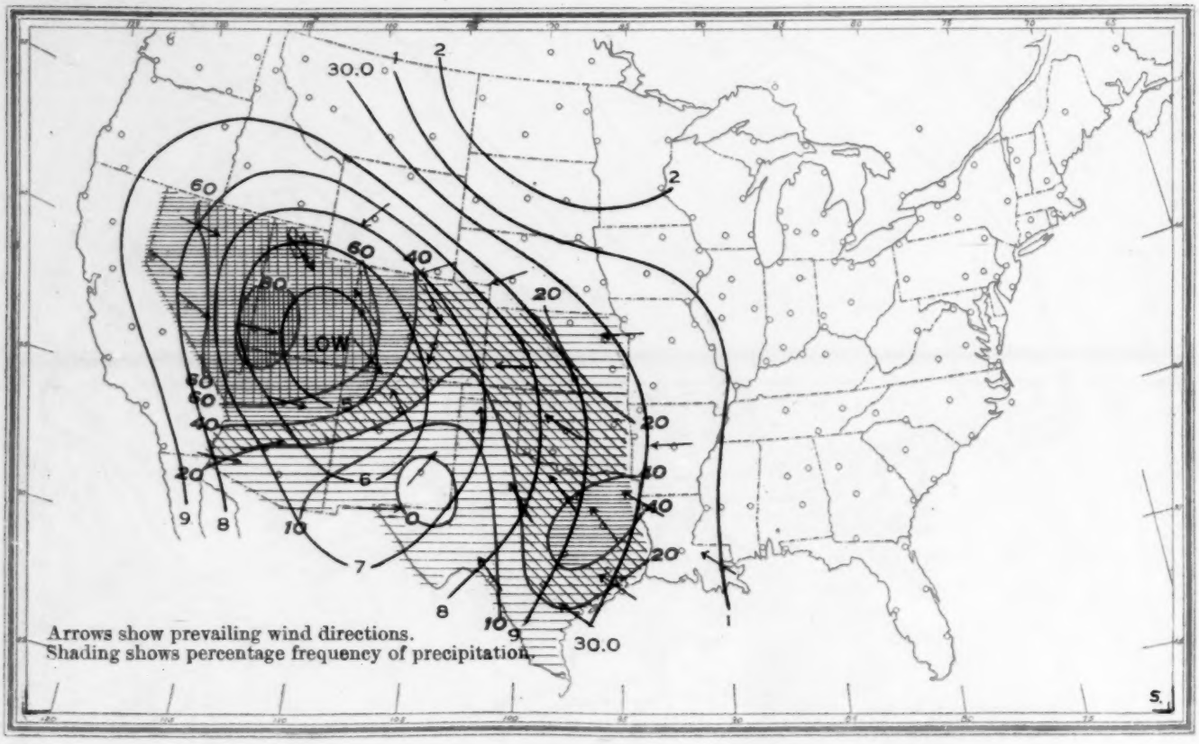


FIG. 2.—Composite of 13 LOWS with areas of greatest depression tangent to northwestern New Mexico.

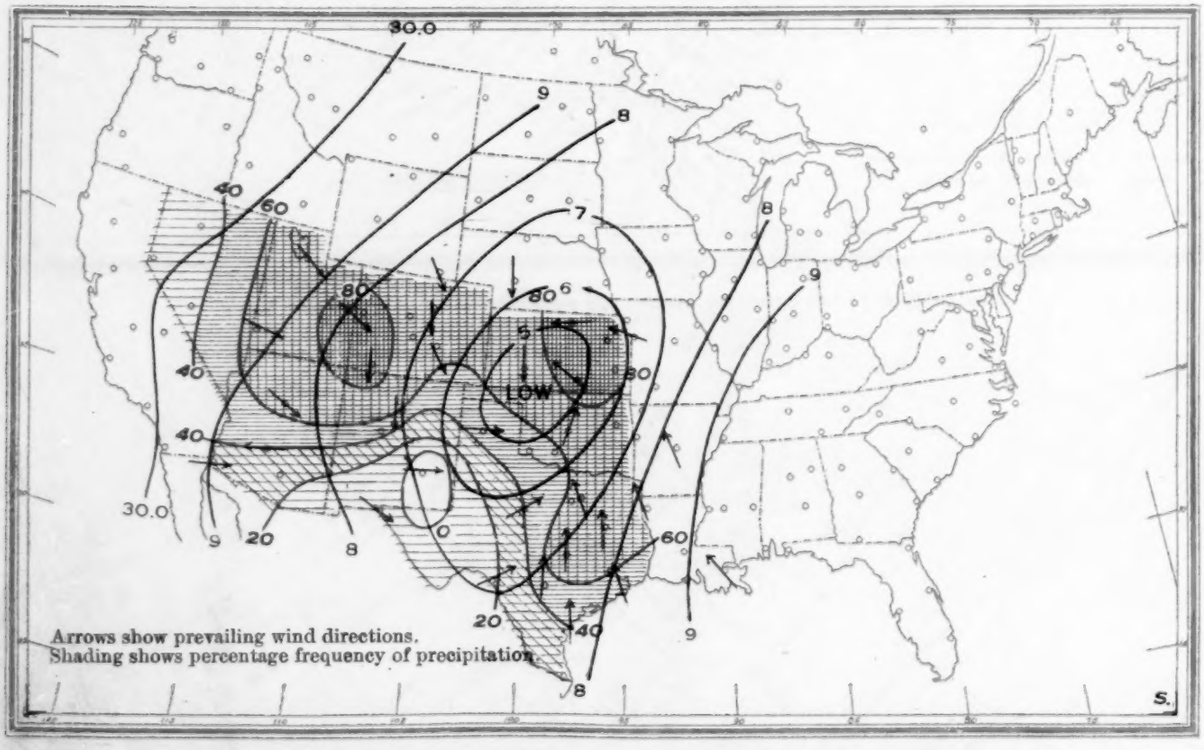


FIG. 3.—Composite of 10 LOWS with areas of greatest depression tangent to northeastern New Mexico.

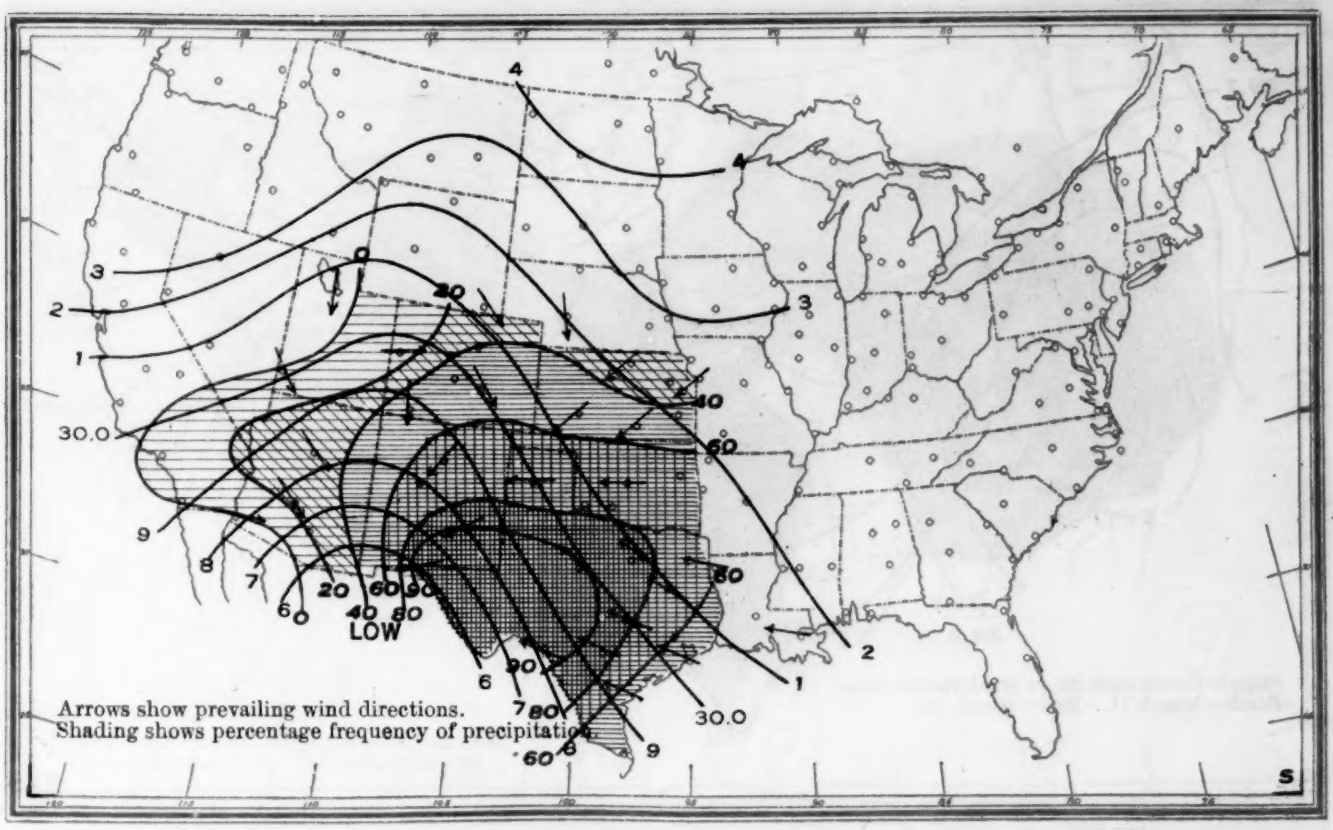


FIG. 4.—Composite of 10 LOWS with areas of greatest depression tangent to southwestern New Mexico.

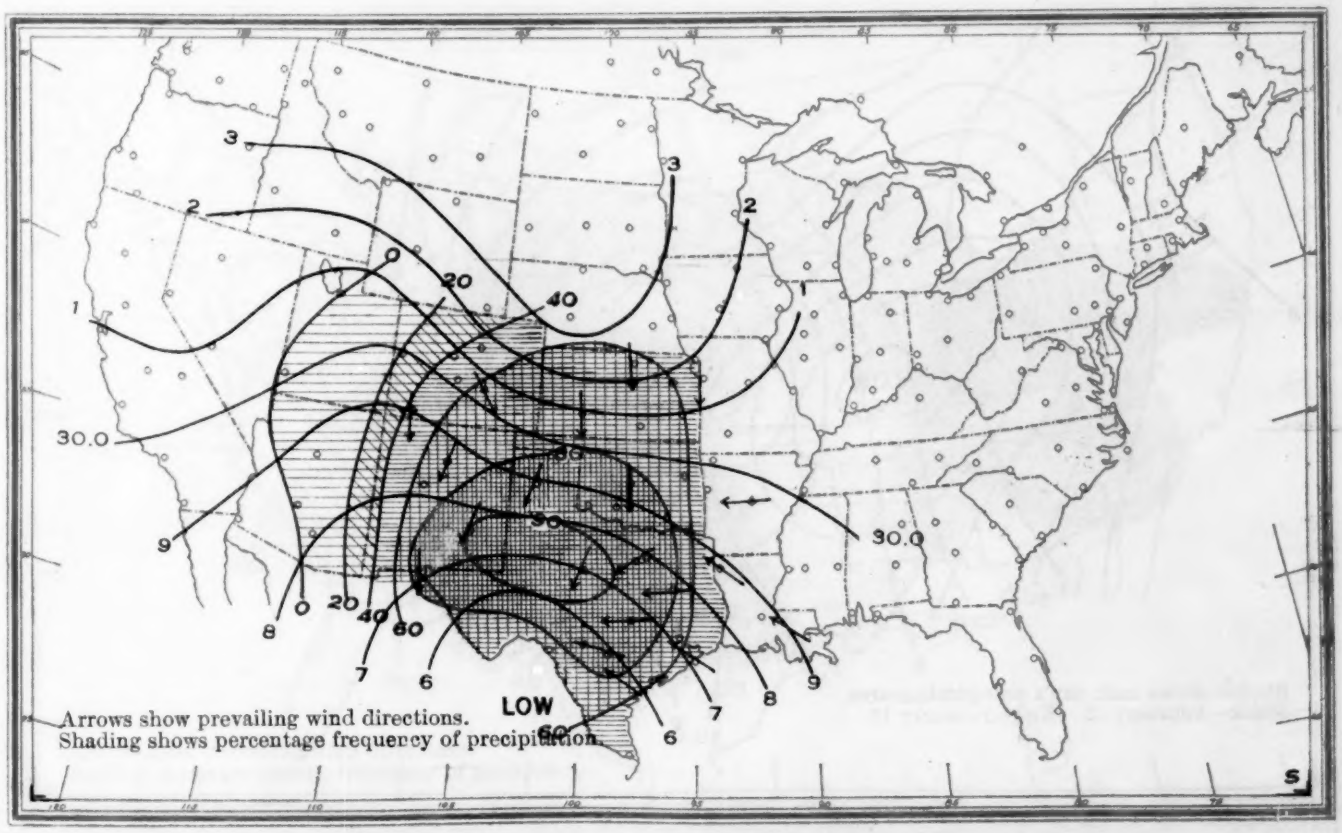


FIG. 5.—Composite of 8 LOWS with areas of greatest depression tangent to southeastern New Mexico.

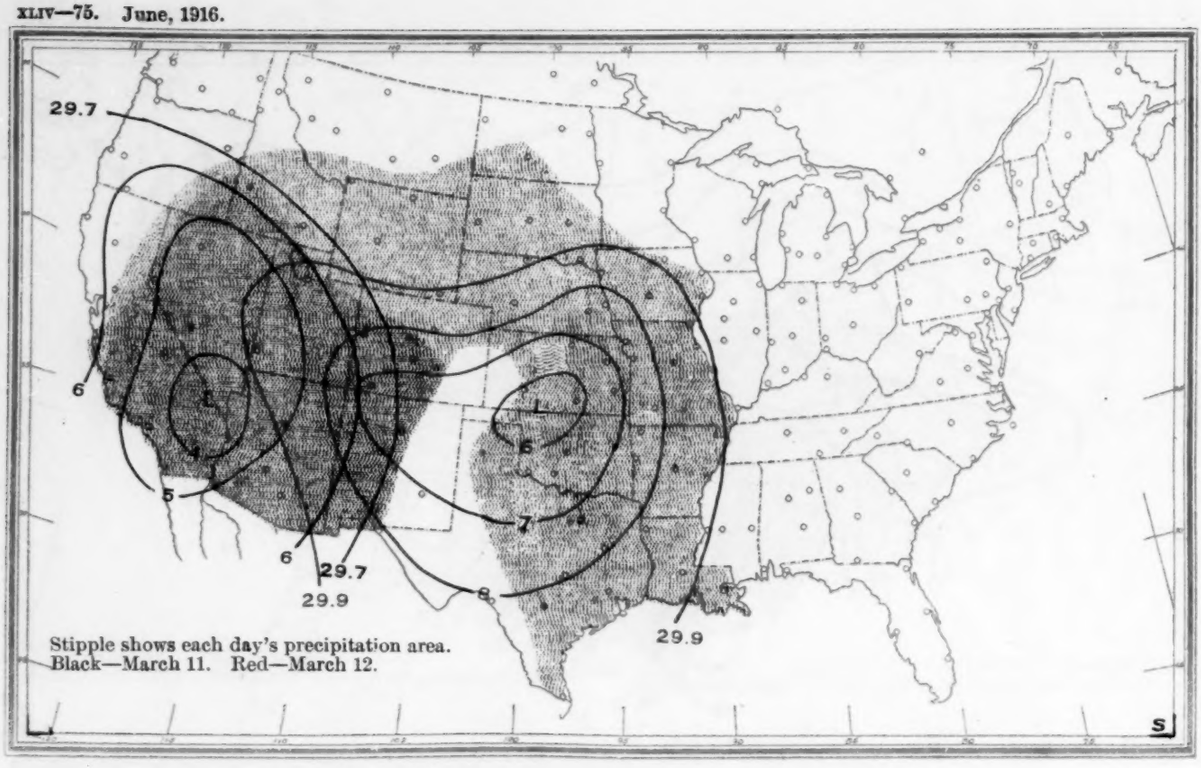


FIG. 6.—Combined pressure and precipitation maps of March 11 and 12, 1912.

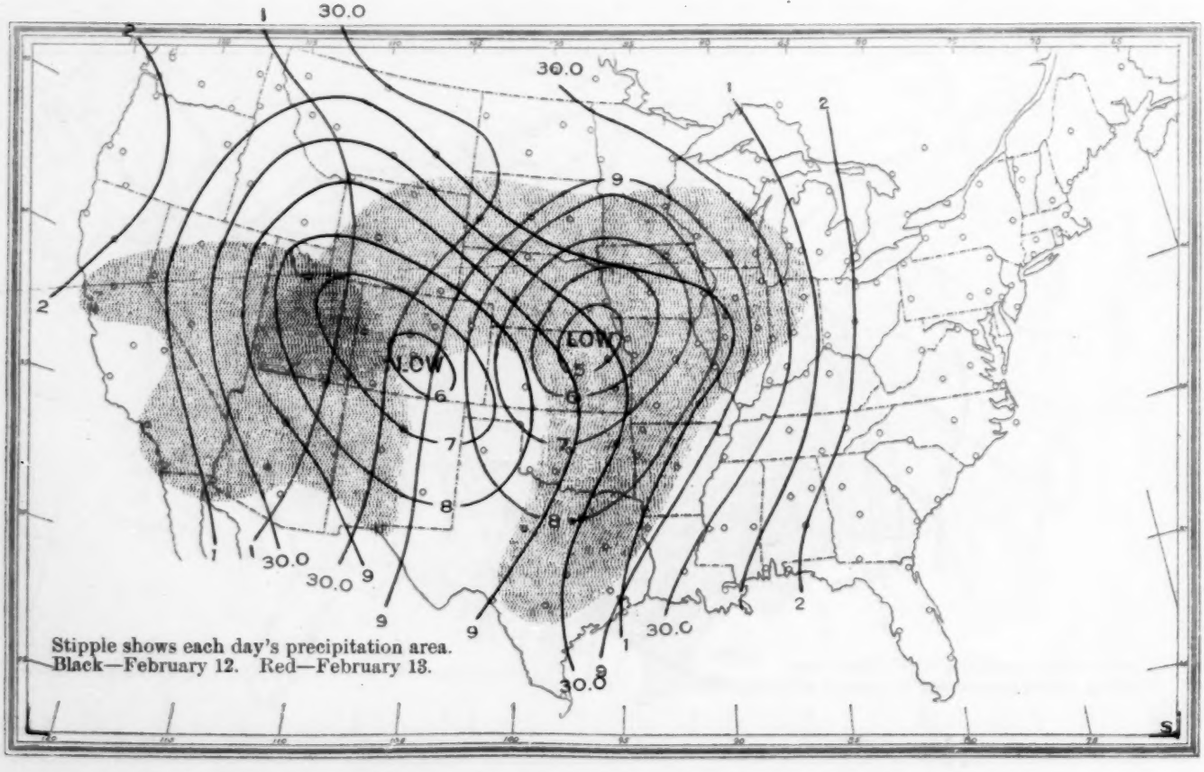


FIG. 7.—Combined pressure and precipitation maps of February 12 and 13, 1915.

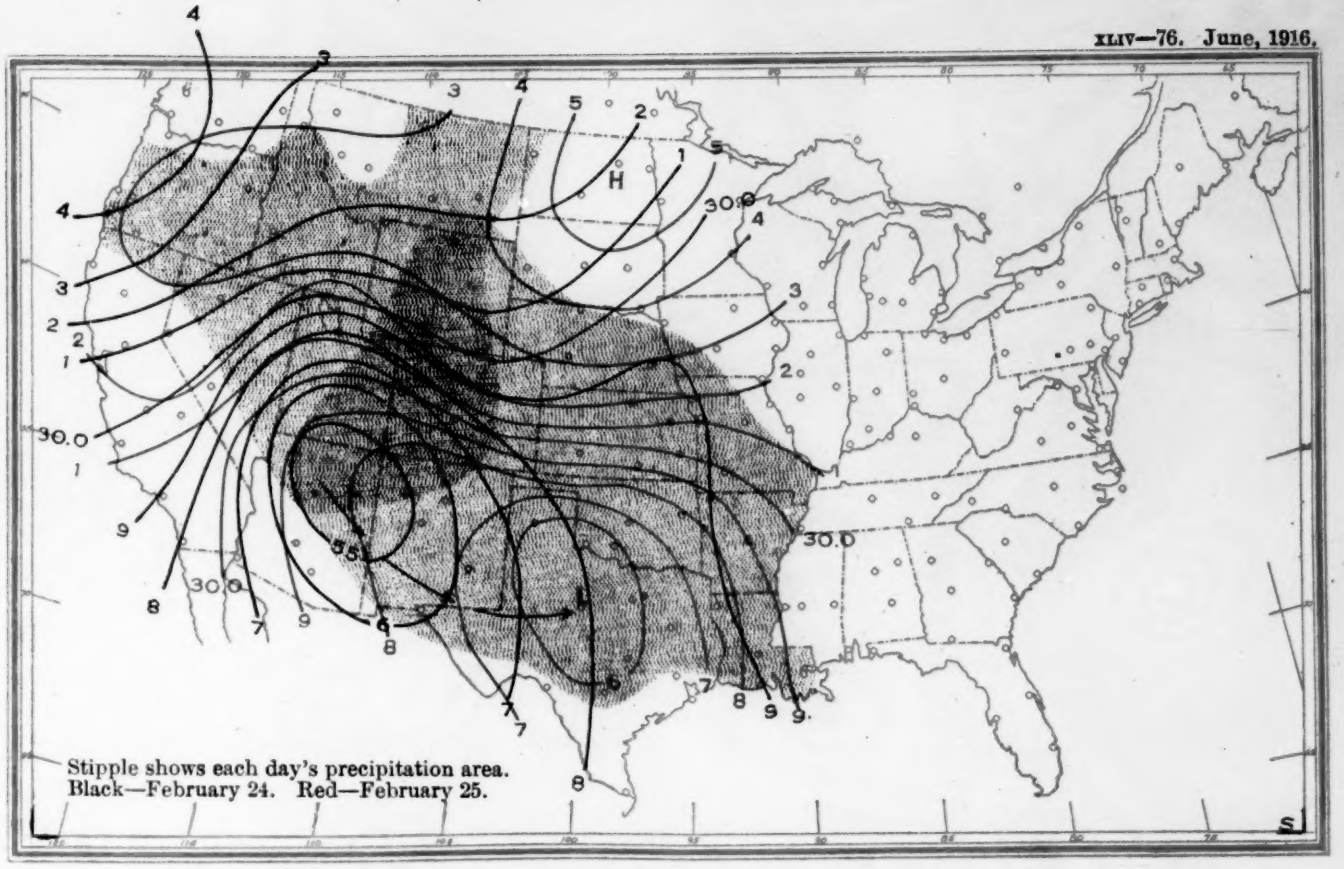


FIG. 8.—Combined pressure and precipitation maps of February 24 and 25, 1912.

The southeastward movement of the LOW produced precipitation over the "dry belt", which would not have occurred had the LOW followed the more usual path eastward.

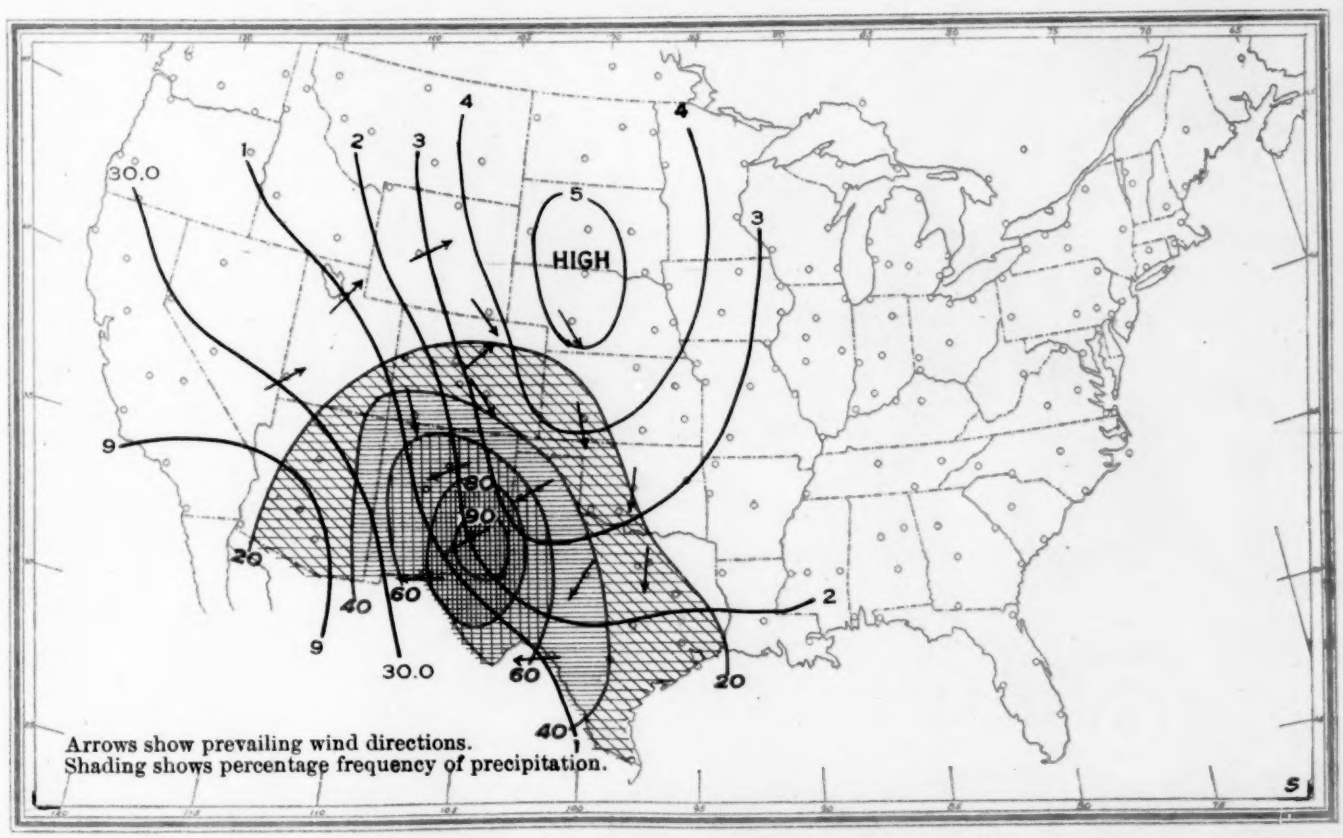


FIG. 9.—Composite of 14 HIGHS that produced precipitation in southeastern New Mexico.